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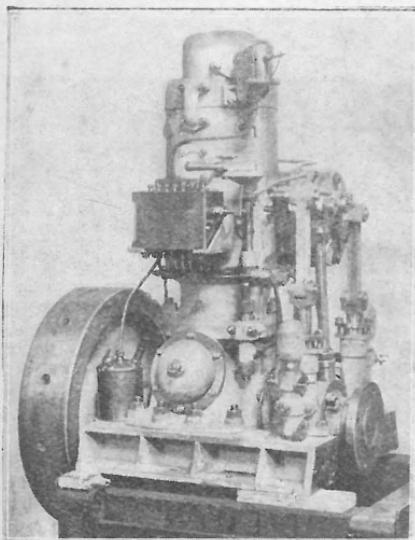


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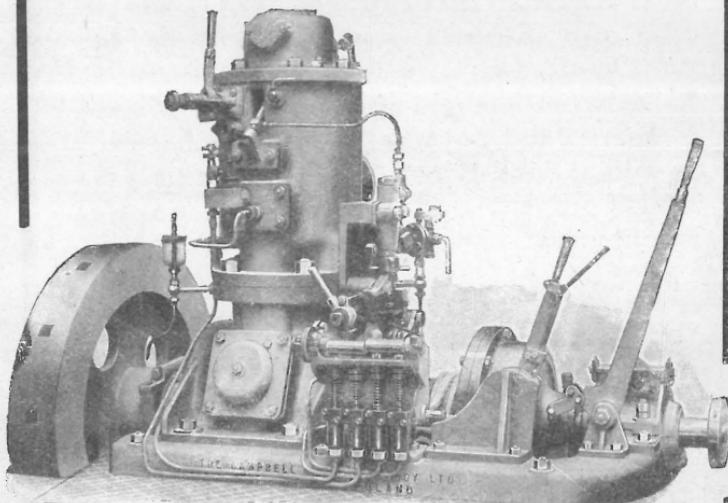
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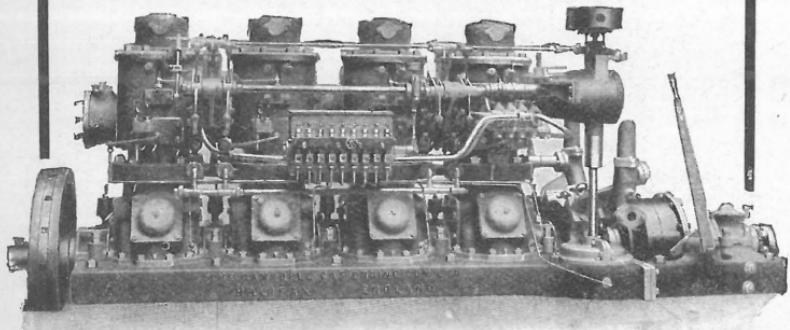
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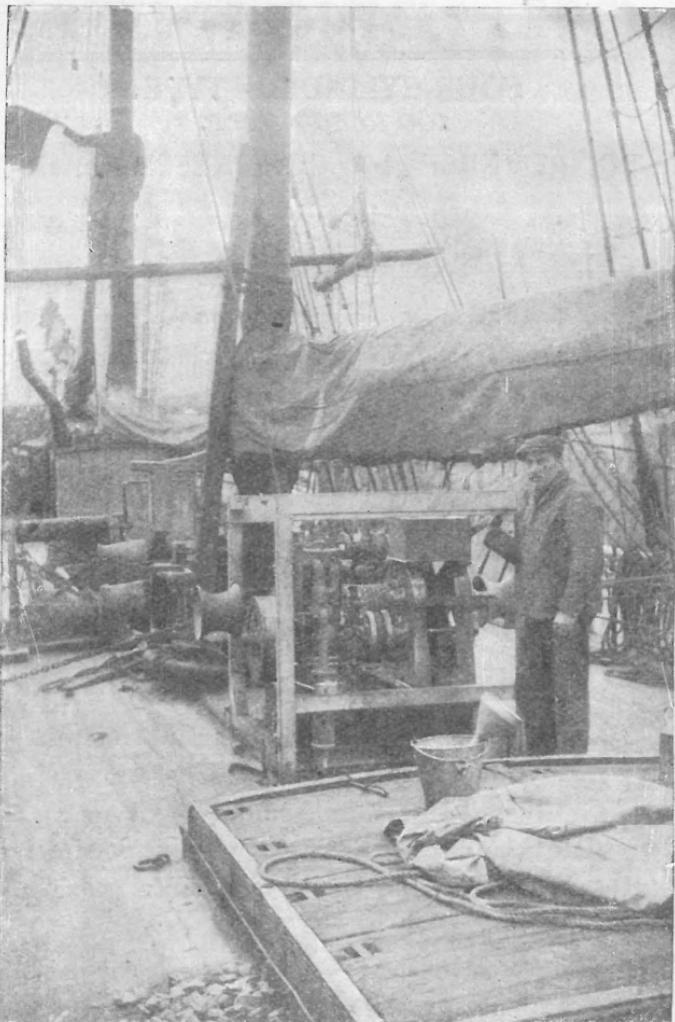
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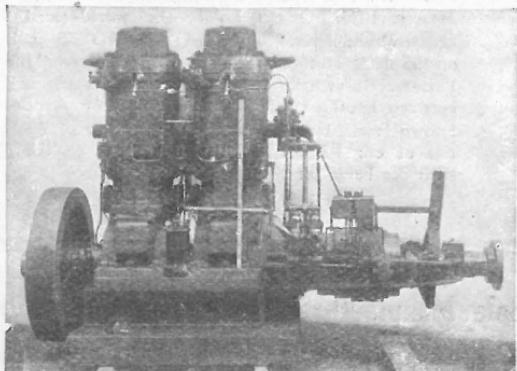
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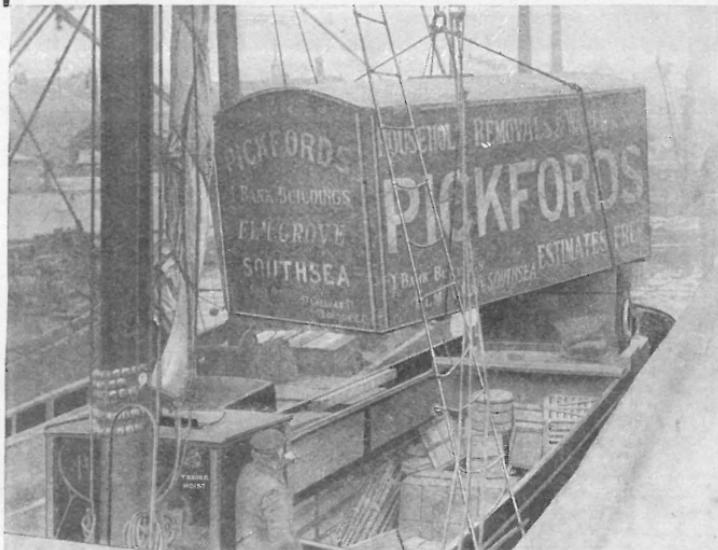
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A WORK OF INSTRUCTION FOR ALL WHO HAVE
TO DO WITH MARINE MOTORS FOR COMMERCIAL
PURPOSES, PARTICULARLY WITH REFERENCE
TO PARAFFIN AND HEAVY OIL MOTORS,
FOR FISHING CRAFT, CANAL BARGES,
AND COASTING VESSELS.

*Compiled by the Staff of
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Third Edition.

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Introduction

AT the time when this handbook was originally published between three and four years ago, the marine oil engine stood in a different position from that which it holds to-day. Although even at that period it was generally admitted that the internal-combustion engine had shown itself very reliable and suitable for pleasure craft and certain types of business boats, it had still to prove in practice that it was specially adapted for the more exacting class of work in commercial vessels of every description. Without taking an exaggerated view of the matter one may fairly claim at the present time that the marine oil engine presents a commercial proposition which it is impossible for those who make use of boats in the ordinary business of life to neglect. But what is most important in the last four years of progress is that we no longer have to prove to the average potential owner that the marine motor is a reliable means of propulsion, since this fact has been so well demonstrated in every part of the world. We need not discuss here the effect of the advent of Diesel engines on large vessels as it hardly comes within the scope of "The Marine Oil Engine Handbook," but the fact should be noted that of every type of modern commercial small boat up to the fairly high-powered motor coaster, in which it was originally a custom either to instal steam engines or in which no motor power at all was provided, is now given over almost entirely to the marine oil engine.

Since its inception, "The Marine Oil Engine Handbook" has found much favour among users of motor craft, and two large editions have been exhausted. With the increasing demand it has been decided to publish a still larger edition, and to render the book thoroughly up-to-date in every respect. With that end in view a good deal of new matter has been introduced, and in particular descriptions of many new heavy-oil engines, some of which have only become of importance since the last edition was published. Certain elementary sections of the book, of course, remain almost unaltered.

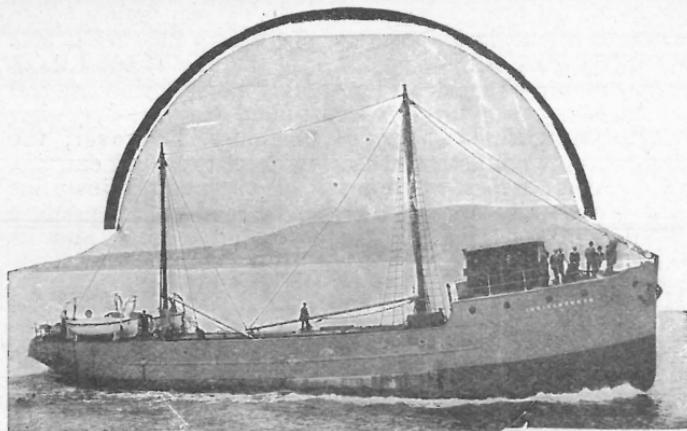
Owing to the rising price in light fuels, the paraffin-petrol engine has become even more prominent than hitherto, because it is uneconomical to use only petrol for commercial craft that have to be run at a profit, and the section dealing with this type of motor will be found to have been considerably augmented.

Motor-driven auxiliaries are now playing an important rôle in the equipment of motor craft, and the new chapter dealing with motor winches will probably be found of special value to many who are unaccustomed to the peculiar characteristics of this type of machine. Moreover, the description with illustrations of various types of existing commercial craft in which marine oil engines are installed should prove of value and interest to readers, in giving a vivid idea of the possibilities of the oil engine, and its suitability for many purposes.

Apart from these additions the scope of the book remains the same, although of course every part has been thoroughly revised and brought up-to-date, a large number of new illustrations being embodied in order to represent the very latest practice in every sphere. Briefly, it may be said that the intention is that the book should form a thoroughly practical guide to all those who have to deal with the operation of a marine oil engine. Whilst it is of course impossible to include details of every type of motor which is made, the description of a comparatively large number together with the chapters which describe in simple terms the principles upon which motors operate and how they should be managed, ought to be sufficient to give a very good idea of the possibilities and limitations of a marine oil engine, and the best means of maintaining it in a high degree of efficiency and reliability.



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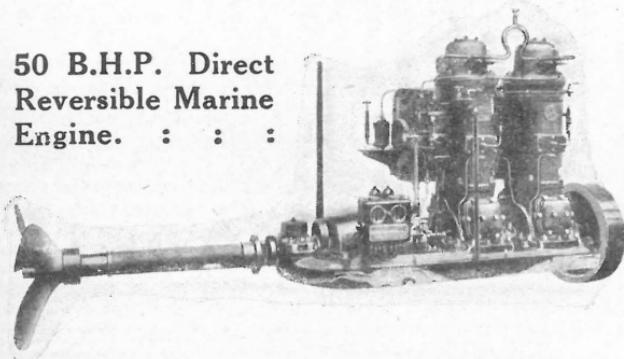
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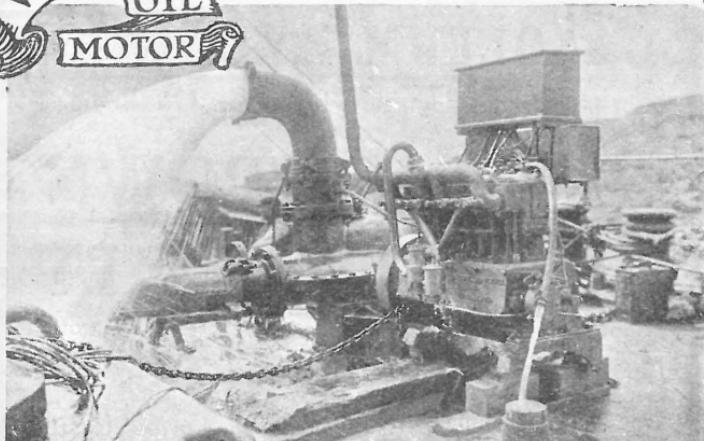


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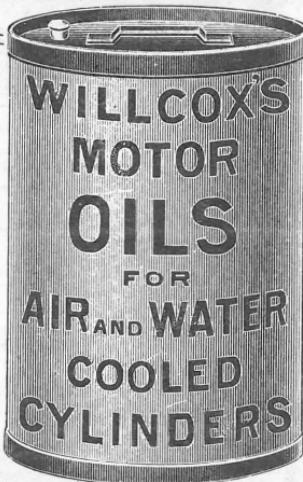
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CHAPTER I

The Marine Motor and How it Works

WHAT is the difference between an oil and a steam engine? That is the question that every man asks himself when first he has to take charge of one. The actual parts of which the two are built are not so very different. The motor has its cylinder (or cylinders), its piston, crankshaft, and connecting rod. Almost always the last is attached direct to the piston, instead of to a cross head, the crankcase of a motor is usually closed because the engine runs faster, and the oiling arrangements that do well for a steam engine will not do for a motor. And the valves of a motor are different. The ordinary slide valve of a steam engine is never used. "Poppet," or mushroom, valves are generally used, so called because they are shaped like mushrooms, with very long stems, or there are ports cut in the cylinder which are covered and uncovered by the piston. A few engines have sleeve valves.

So far, then, a motor may be looked upon as a single-acting steam engine. There is nothing mysterious about it. The moving parts act in exactly the same way. The only difference is in the means by which the piston is caused to move. In a steam engine, steam at high pressure is supplied by a boiler, being let into the cylinder through a valve at the beginning of each stroke. In a motor no pressure is raised outside the cylinder. Air is admitted through a valve, and with it the right amount of fuel, either petrol, paraffin or a heavier oil. Once the two are in the cylinder the valve is closed; they are exploded or burned in the cylinder, and the force of the combustion drives the piston down, just as steam drives the piston of a steam engine. Once the explosion is over, another valve is opened to let the burnt mixture of air and oil escape. This mixture corresponds with the exhaust steam of a steam engine.

That is the great difference between a steam engine and a motor. The pressure to drive the piston of a steam engine is obtainable from a boiler; in a motor the pressure is produced inside the engine itself, and so all the weight and room taken up by a boiler is saved. It will now be easy to understand a term that must puzzle a good many people. A motor is often called an "internal-combustion engine." The expression simply means that burning or combustion

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of the fuel takes place inside the engine instead of outside it, and oil is burned instead of coal.

What has been said answers the question "What is a motor?" But there is a good deal yet to be explained. We have seen that oil and air are taken into a cylinder through a valve, that an explosion then takes place which drives the engine, and that after the explosion another valve is used to get rid of the "exhaust." But we do not know yet how these valves are worked, or how the explosion, or "ignition," as it is generally called, is produced. How a motor works will be explained in a separate chapter.

The Four-stroke Cycle Engine

By looking at Fig. 1 we get an idea of what a four-stroke engine is like inside. The cylinder is shown in "section," that is, cut in half from top to bottom, exposing the piston, connecting rod and crankshaft, the last being seen from one

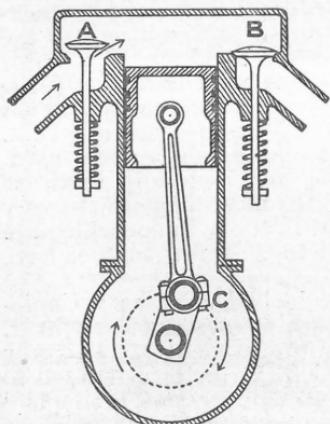


Fig. 1.

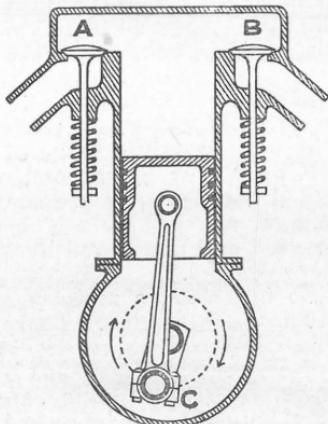


Fig. 2.

end, and one of its bearings shown by a thick black line. On either side of the top of the cylinder are the valves, marked A and B, held down by spiral springs as shown. The valve (A) is supposed to have just been pushed open from below, though it is not shown here how this has been done.

The Suction Stroke

Now, we will suppose the engine to be turning round in the direction shown by the arrows. The crankpin (C) is just past the top of its stroke, but after half a turn it will be in the position shown in Fig. 2, and the piston will have made one down stroke and is just starting to move up again. The valve (A) is now shown closed, the mechanism by which it was held open having released it at the end of the down stroke. It will be understood now that the piston has sucked in air through the valve (A), which is called the

HOW A MOTOR WORKS

inlet valve, and that this air is now imprisoned in the cylinder. Now, the pipe leading to A is connected to a specially-constructed vessel, containing paraffin or petrol, so arranged that the air drawn in by the piston takes the right amount of paraffin (or petrol) with it, so that we really have not pure air, but a mixture of air and paraffin imprisoned in the cylinder. This mixture is explosive, and in future will be called simply "gas," that being the name by which it is usually known. The vessel in which the air takes up the paraffin or petrol is called a "vaporizer," or "carburetter," according to the way it is made. We will explain how it works later.

So far, then, our engine has made one down stroke, and has sucked a charge of "gas" into the cylinder. This is what is known as the *suction stroke*.

The Compression Stroke

Now, with the piston just commencing to move upwards, it is clear that an explosion above it would stop the engine turning instead of driving it, so nothing is done to fire the

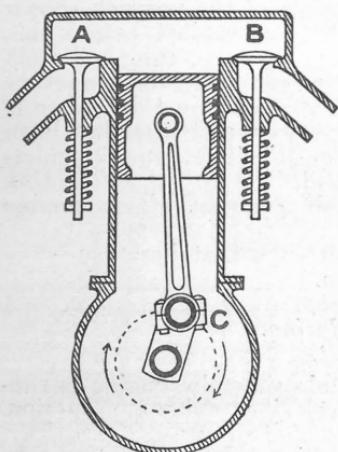


Fig. 3.

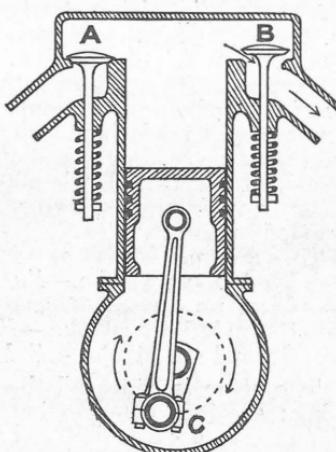


Fig. 4.

gas. Both valves being closed, the gas is simply compressed in the space above the piston until the piston reaches the top of its stroke. This is the *compression stroke*.

The Explosion Stroke

We have now reached the position shown in Fig. 3, the same as Fig. 1, except that the valve (A) is closed. It will be seen that if the gas compressed in the cylinder head is exploded it will drive the piston down and keep the engine running. This is exactly what happens, and the explosion is much more powerful than it otherwise would be, because

the gas is already compressed. There is no need to explain just now exactly what causes the explosion to take place. It can be produced either by an electric spark or by a hot tube or bulb screwed into the cylinder, but we will go into that later. For the present we will simply assume that the explosion does take place, and that the piston is driven downwards. This is called the *explosion* or *firing stroke*.

The Exhaust Stroke

The engine now comes to the position shown in Fig. 4, the same as in Fig. 2, except that the cylinder is now full of burnt gas, or *exhaust*, as it is called, instead of an inflammable mixture. The next thing to do is to get rid of the "exhaust," and to do so the "exhaust valve" (B) is used. It is opened at the end of the firing stroke, and is shown open in Fig. 4. Again, we will not worry about the way this valve is opened, but will only say that it is done in the same way as the valve (A). Now the piston begins to move upwards, and in doing so forces the "exhaust" out through the open exhaust valve. This is what is known as the *exhaust stroke*.

After it—the piston—arrives again at the position shown in Fig. 1, the exhaust valve (B) closing just before this position is reached, and the inlet valve opening immediately afterwards. The engine is then ready to commence another *suction stroke*, and the same set of strokes just described is repeated. That is how a motor works, and what has been said must be read over and over until it is thoroughly understood. Until the idea is mastered, it is no use attempting to go any further, for the whole running of an engine depends upon it.

To sum up. There are four things that happen:—

First down stroke.—*Suction*.

First up stroke.—*Compression*.

Second down stroke.—*Explosion*.

Second up stroke.—*Exhaust*.

The same is repeated the whole time the engine is running: suction, compression, explosion, exhaust; suction, compression, explosion, exhaust, and so on.

Now, these four strokes are, of course, equal to two complete revolutions of the engine, so that an explosion only takes place on each alternate revolution, and a motor that works in this way is known as a *four-stroke-cycle motor*.

Valves of a Four-stroke Motor

We have mentioned that special mechanism is used to open and close the valves of a motor. We will now explain it. Figs. 1 to 4 show, roughly, how the ordinary "mushroom" valve is arranged, and an enlarged view is given in Fig. 5. We have seen that there is an explosion only every other revolution, and in exactly the same way each of the valves is open for one stroke (half a turn of the engine) every other revolution. Fig. 5 shows how the valves are

HOW A MOTOR WORKS

opened and closed. A ring is cut in the cylinder casting (marked D), on which the mushroom-shaped head of the valve rests, this being known as the *valve seating*. There is a stem (E) to the valve, which passes through a guide (F), which keeps it central. To hold the valve down on its seating there is a spiral spring bearing against the bottom of the guide, and against a collar (H) near the bottom of the valve stem. To open the valve it has to be pushed up from below, which is done by the rod (K), this being known as the *valve tappet* or *tappet rod*. It is carried, as shown, by a guide (L) in the crankcase casting, and its lower end is fitted with a roller (M).

Underneath this roller is a shaft (N) carrying a disc or collar (O), on which the roller (M) rests, as shown on the right-hand side of Fig. 5. The length of the tappet is such that it is just clear of the valve stem when the roller rests on the collar (O). To open the valve there is a hump (P) on the collar, and as the shaft (N) rotates this hump passes under the roller (M), lifting the tappets and opening the valves. The hump (P) is called a *cam*, and the shaft (N) on which it runs is a *camshaft*.

Now we have seen that the valve has to open *every other revolution of the engine*, and it is also clear that the valve will be opened on *each revolution of the camshaft*, so that the camshaft must turn at *half the engine speed*. This is

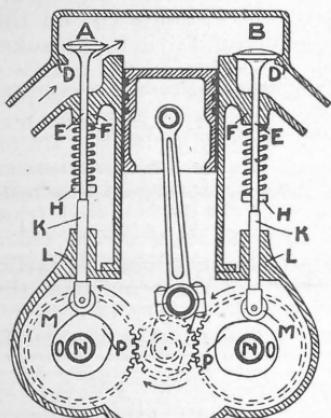


Fig. 5.

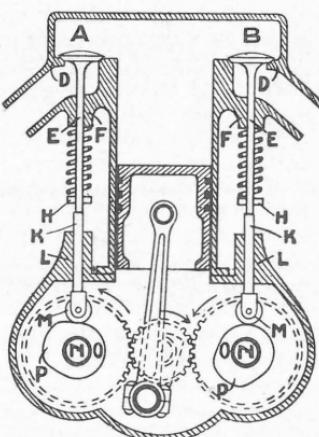


Fig. 6.

done simply by driving the camshaft off the crankshaft through two-to-one gearing, ordinary toothed wheels, and sometimes wheels and chains, being used. These wheels, called the *two-to-one gear*, are shown by dotted circles in Fig. 5.

It has been explained that a valve must remain open during one stroke; that is, half a revolution of the engine. Now, since the camshaft turns at half engine speed, it will

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only make a quarter of a revolution while the piston makes one stroke, so that, to hold the valve open for half a revolution

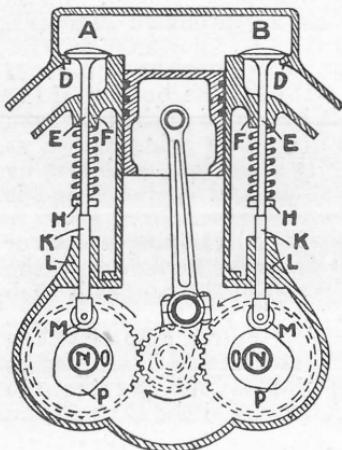


Fig. 7.

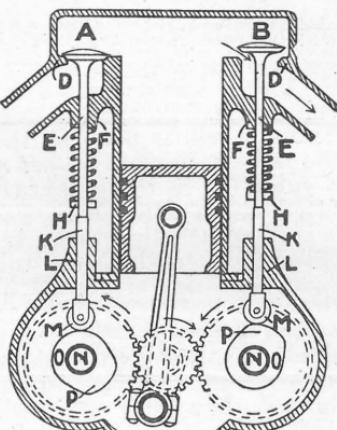


Fig. 8.

tion of the engine, the cam (P) must extend a quarter of the way round the collar (O). Fig. 5 will make this clear. The inlet valve (A) is on the left, the exhaust (B) on the right, and the engine is just commencing its suction stroke. The direction in which the wheels of the two-to-one gear are turning is shown by arrows. The inlet valve cam has just opened the valve (A), and the exhaust valve cam has just released the valve (B), allowing it to close under the action of its own spring. Fig. 6 shows what has happened after half a revolution of the engine. The compression stroke is just beginning. The inlet valve cam (P) has passed from under its tappet, and has just cleared it, allowing the valve (A) to close. The exhaust camshaft has also made a quarter of a turn. Fig. 7 shows the positions of the cams after the next half revolution. The firing stroke is just beginning, and both valves are still closed, but each cam has made another quarter turn.

Fig. 8 shows what has happened after another half turn of the engine. The firing stroke is over, and the exhaust stroke is just commencing. It will be seen that the exhaust cam has just reached its tappet and has opened the valve (B). The next half turn brings us back to Fig. 5.

That is all there is to understand in the four-stroke engine. It is really quite simple, though it takes some time to explain in writing. In the drawings we have shown a separate camshaft for each valve, but valves are often placed side by side instead of on opposite sides of the cylinder, and are worked by a single camshaft, on which are two cams instead of one. Also with some engines the inlet valve is directly over the exhaust valve and is worked by means of a rocker

HOW A MOTOR WORKS

on the cylinder head, via a long push-rod from the cam-shaft; but these different arrangements are purely a question of personal choice of the designer or maker.

Again, on some engines the inlet valve is not worked by a cam in the way we have described. If we make its spring very weak, the suck of the piston is enough to open the valve on the suction stroke and allow gas to enter. Directly the compression stroke begins this suction stops and the valve closes. This is called an *automatic inlet valve*.

In practice the valve setting is not quite as we have described. The exhaust is set to open just before the end of the firing stroke, and the inlet valve often does not close until the compression stroke has just commenced. Valves are, in fact, given "lead" just as in a steam engine.

Engines with Two or More Cylinders

The working of a motor with two or more cylinders is exactly the same. Each cylinder has its own valves, and works independently of its neighbours. Unlike a steam engine, the cranks are never at right angles, but are oppo-

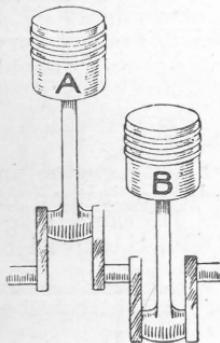


Fig. 9.

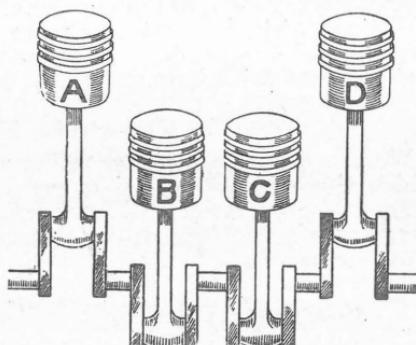


Fig. 10.

site each other, so that when one piston is at the top of its stroke, another is at the bottom. Fig. 9 shows a diagram of a two-cylinder motor, the pistons and connecting rods being shown attached to the crankshaft with the cylinders removed. Suppose the piston (B) has just finished its firing stroke. While it is ascending again on its exhaust stroke, the piston (A) will descend on its firing stroke. Then, while B is on the suction stroke, A is on the exhaust stroke, and so on. The following table will make the matter quite clear:—

Piston A.	Piston B.
Suction.	Compression.
Compression.	Explosion.
Explosion.	Exhaust.
Exhaust.	Suction.

It will be noticed that a two-cylinder motor does not give an explosion each revolution. Two explosions take place in

one revolution, and there are none in the next, so that the engine runs: fire, fire, miss, miss, fire, fire, miss, miss.

The crankshaft of a four-cylinder motor is shown in Fig. 10. Pistons A and D move up and down together, and B and C do the same. In the diagram, we will suppose A is going to begin its firing stroke, then D must be going to commence its suction stroke. Then, if B is starting its compression stroke, C is starting its exhaust stroke. After half a turn B fires, and D makes its compression stroke, while C is on the suction stroke. Then D fires while C makes its compression stroke. Then C fires. The order of firing is, therefore, A, B, D, C. It would have been possible to change round B and C in the first place. For instance, when A fired, B might have been starting its exhaust stroke, while C was starting its compression stroke. In that case the order of firing would have been A, C, D, B.

Some engines are set one way, some the other; it is simply a question of how the cams are arranged, and these are the only two possible orders of firing. It is easy to tell in which order the cylinders fire by turning the engine slowly and watching the order in which the valves open, starting from whichever end of the engine is most convenient.

Engines with three, six, or more cylinders are not very often met with in trading vessels, so we will not worry about their order of firing here.

The Two-stroke Engine

We now come to a rather different sort of oil engine, in which there is an explosion every revolution instead of every other revolution with each cylinder. The same things happen as in the four-stroke motor—suction, compression,

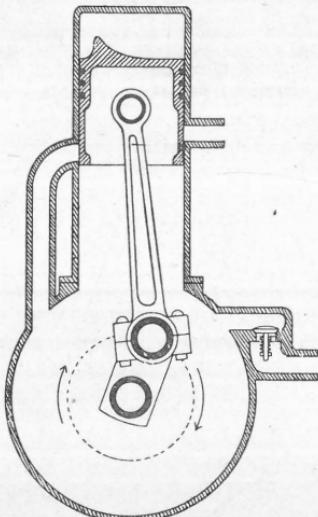


Fig. 11.

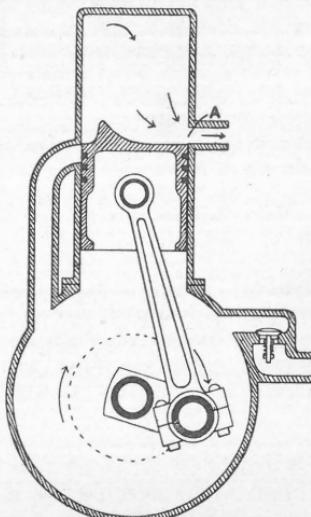


Fig. 12.

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explosion, exhaust, and so on ; but, instead of each of these taking a complete stroke, they are all four carried out in two strokes, that is, in one complete revolution of the engine. That is why this class of oil engine is called a "two-stroke motor."

Fig. 11 shows what a two-port engine is like. We will suppose the engine to be turning in the direction shown by the arrow, and that an explosion has just taken place. The piston is at the top of its stroke and just commencing to come down. Now the case carrying the crankshaft is enclosed and the part of the cylinder below the piston is full of gas, that is, an explosive mixture of air and petrol. How this gas is got into the crankcase we will explain later ; for the present we will simply suppose it is there. As the piston descends this gas is compressed into a smaller space, and so will rush out of any opening it can. We will leave this compressed gas where it is for a minute, and see what is happening above the piston.

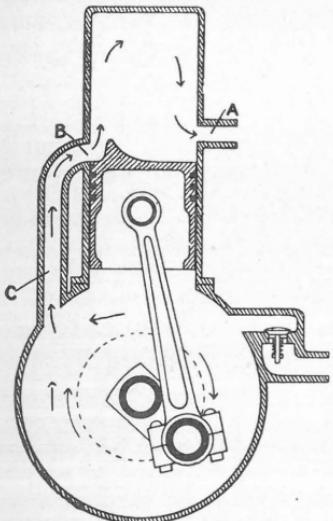


Fig. 13.

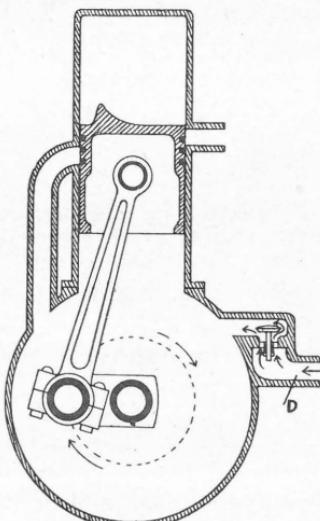


Fig. 14.

We supposed that an explosion had taken place just as the piston had begun to descend. When it reaches the position shown in Fig. 12 it exposes an opening, or port, as it is called (marked A) in the side of the cylinder, and through this port the burnt gas, or exhaust, escapes. This port is, therefore, called the exhaust port.

Next we come to Fig. 13. Here the piston has moved still lower, and is almost at the bottom of its stroke. It will be seen that it has opened another port (marked B) on the other side of the cylinder. This port is connected by the pipe (C) with the crankcase, where, as we have seen,

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there is compressed gas waiting to get out when it can. This gas, therefore, rushes up the pipe (C) into the cylinder, driving out all that remains of the exhaust through the port (A), and filling the cylinder with fresh gas. On the up stroke the port B is closed first, then port A, and the gas in the cylinder is compressed more and more, until the top of the stroke is reached. We then get back to the position shown in Fig. 11. The gas is exploded, the piston is driven down, and so the engine goes on running.

In these drawings it will be noticed that there is a curious shape given to the top of the piston. This is called a baffle, and is used to make the gas entering at B sweep upward and scavenge the cylinder, instead of blowing straight across to the exhaust port, and being wasted.

We will now explain how gas is got into the crankcase. Fig. 14 shows a mushroom valve like those used in the four-stroke engine, but fastened to the crankcase instead of to the cylinder. It is held down by a spring, but this spring is very weak, a very slight suck above the valve being enough to open it. The pipe (D) below the valve is connected to a carburettor or vaporizer, just as if it were the inlet valve of a four-stroke motor, and when the valve is open gas passes through it.

Suppose now the piston is at the bottom of its stroke. As it moves upwards it will make a space or "vacuum" in the crankcase. This sucks the valve open, and allows gas to rush through. The next time the piston comes down it compresses this gas, which cannot get out again through the valve, and so we see why it is there is always compressed gas in the crankcase ready to rush into the

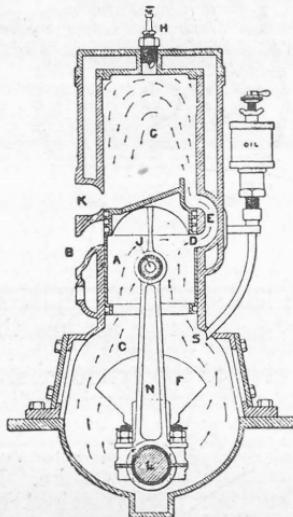


Fig. 15.

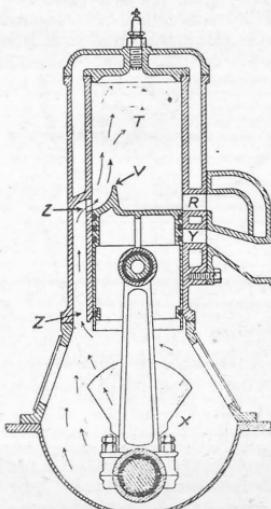


Fig. 16

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cylinder when the inlet port (B) is opened at the bottom of the stroke.

That is all there is in a two-port two-stroke motor. It is simpler than a four-stroke engine, because there are no valves in the cylinders, and it has the advantage of giving an explosion each revolution. It may be asked why a four-stroke motor is ever used, if the two-stroke is so simple. We need not explain the reasons here. It can only be said that both these kinds of oil engine have good points of their own, and there is really very little to choose between them. Some men prefer the four-stroke, some the two-stroke. Naturally the latter has a slightly higher fuel consumption, and while giving more power for the same bore, stroke and revolutions, it is not anything like double. On the other hand the four-stroke type will give more power for the bore and stroke, as it can be run at a much higher speed with success.

The Three-port Engine

There is a rather different class of two-stroke engine made in which there are three ports instead of two, and which is therefore known as the "three-port" type. In this case there is a port in the side of the piston itself, through which the gas passes from the crankcase to the cylinder instead of going through an outside pipe as in the engine just described; also gas is taken into the crankcase through the port (B) when the piston is at the top of its stroke. Otherwise the working of this engine is exactly the same, so there is little need for the user to worry about the difference.

However, even three-port two-stroke motors vary slightly in design and arrangement, as will be seen by comparing Fig. 16 with Fig. 15. In the latter there is a port in the side of the piston to admit the mixture of air and gas from the crank chamber (X), but in Fig. 16 there is no port in the piston. When the piston reaches the bottom of the stroke the port (Z) is open, and as this port communicates direct with the crank chamber the gas is admitted into the combustion chamber (T), and deflected upwards by the lip-shaped piston top (V). At the same time the port (R) on the opposite side of the cylinder is opened, and the exhaust gases pass out, assisted, of course, by the pressure of the fresh mixture entering at (Z). When the piston is at the top of the stroke the port (Y) is open, and fuel and air is admitted from the carburetter into the crank chamber, where it is compressed ready for entering the passage (Z) on the down stroke.

We have now tried to explain how both kinds of oil engine work, and we hope the reader has understood. If he has not, he should read all that has been said over again. It is well worth while to spend a week or a month, if necessary, over it, for if one really understands how a motor works, it is much easier to keep it in order.

CHAPTER II

Vaporization of Fuel

Vaporizers and Carburetters

WE have mentioned the explosive mixture of "gas" that is used in a motor, but we have not explained how it is made. The arrangement in which the gas is prepared is called a vaporizer or carburetter, according to the way it is made, and almost every maker of an oil engine has a special vaporizer or carburetter, which he designs to suit his own motor. It will not, therefore, be much use to describe any one kind, because all the other patterns would differ from it. We will, however, explain the general idea on which all are made.

The Difference between Carburetters and Vaporizers

All carburetters and vaporizers depend on air being sucked through them by the suction stroke of the engine. In passing through, it is arranged that the right amount of fuel shall be mixed with the air, and what the vaporizer or carburetter has to do is to convert the liquid fuel into the form of vapour or very fine spray, so that it will mix with the air and form a sort of mist. There are two ways in which this may be done, either by heating the fuel or by spraying it through a very fine jet. Here lies the difference between a carburetter and a vaporizer. A vaporizer heats its fuel, but the carburetter sprays it. Petrol is the only fuel that can be used without any heating at all.

A Simple Vaporizer

Now, most commercial motors use paraffin or heavy oil as fuel, so we will first consider some kinds of vaporizer suitable for paraffin. We will start with the simplest possible vaporizer. Fig. 1 represents an ordinary four-stroke motor, A being the exhaust pipe and B the inlet pipe. There is a jacket or outer pipe (marked C) surrounding the exhaust pipe, and this jacket is open at its lower end to the air, while the inlet pipe (B) leads out of the top of it. If we suppose the engine to be running, the exhaust pipe will, of course, be hot; the suction of the piston will draw air through the jacket (C) and the pipe (B), and this air will be warmed by passing over the exhaust pipe.

On the top of the jacket is a very small screw-down stop-valve (D); in fact, it is so small that it is always called a

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needle valve. It is connected to the fuel pipe (E), which brings paraffin from a tank, and, by setting the valve (D) carefully, just the right amount of paraffin will be allowed to drip through on to the exhaust pipe. Practice will show what opening of the valve makes the engine run best.

The paraffin, dripping on to the hot exhaust pipe, is turned into vapour, just as a water drip would be turned into steam, and, mixing with the warm air, it passes into the cylinder in the form of "gas." This gives an idea of the simplest possible vaporizer; in practice, they are not quite so simple, but once the main idea is understood, there will be no difficulty about other points. For example, the paraffin is made to mix much better with the air if the draught is very great, so the jacket (C), where it passes the paraffin drip, might be made much smaller, leaving only a small opening through which the air would rush very fast.

Again, if the needle valve be set to give the right amount of paraffin when the engine is running at one speed, the amount will not be right when the speed alters. Suppose 10 drips a minute are wanted at 200 revolutions per minute (usually written 200 r.p.m.), if the speed is altered to 400 r.p.m., 20 drips a minute will be wanted. It would be a great trouble to have to alter the needle valve every time the engine speed was changed, so this difficulty is almost always arranged for by the designers.

Self-regulating Fuel Supply—Float Feed

The commonest way of obtaining a self-regulating fuel supply is by using what is called a float feed, which acts in exactly the same way as the ball-cock of a cistern. Fig 2 shows the arrangement. This is a round metal box (A) called the *float chamber*, fitted with a lid (B), under which are hinged at the points (C C) two little levers carrying small weights (D D) at their outer ends. Their inner ends are fastened to a rod (E), pointed at its lower end and called a *needle*, and passing through the lid of the float chamber. The point of the needle fits in a hole at F in the bottom of the float chamber, and the fuel-supply pipe (G) is screwed on at this point. The little weights (D D), being heavier than the needle (E), drop down and lift the needle, and paraffin flows into the float chamber. So far, we have

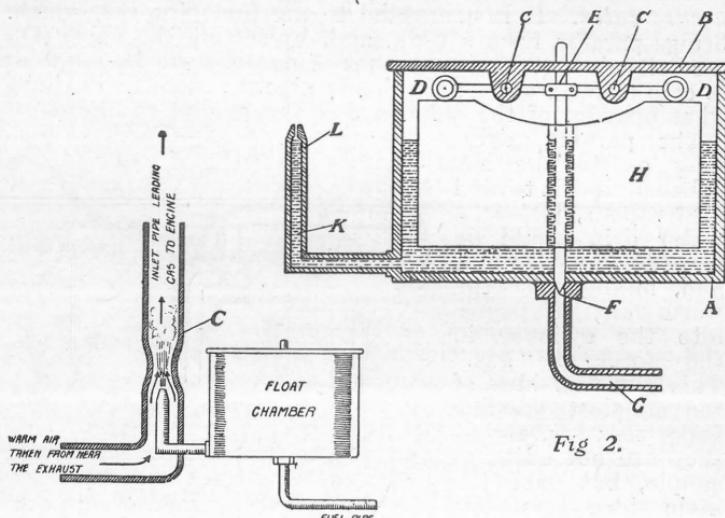


Fig. 3.

Fig. 2.

said nothing about the float (H), which is inside the float chamber, and which takes the place of the ball inside an ordinary cistern. This float is lifted by the paraffin, and at last lifts the weights (D D), as shown in Fig. 2. The needle then drops, and stops any more paraffin coming in.

The Jet

On the left will be noticed a pipe (K), connected to the float chamber, with a small hole (L), called the jet, at the top. This jet is very slightly above the level of paraffin in the float chamber, but the slightest suck over the jet draws out paraffin. The level in the float chamber always remains the same, more paraffin entering as it is wanted, and so the amount of paraffin taken out of the jet depends on the strength of the suction over it.

We must now turn to Fig. 3, which shows the jet and float chamber again, but with a pipe (C) surrounding the jet and taking the place of the jacket (C) in Fig. 1. The jet takes the place of the needle valve (D) in Fig. 1. The engine draws warm air through the pipe (C), which, it will be noticed, is smaller just above the jet, and so produces a very powerful suck. Paraffin is drawn up in a spray and mixed with the air.

Now, if petrol instead of paraffin were being used, this "gas" could be taken straight to the engine, but with paraffin some extra heat is wanted. So far, the paraffin has not been turned into vapour; it has simply been broken up into very small drops, and is being carried along by the air. In some vaporizers the air and paraffin are led over a pipe kept hot by the exhaust; in others a baffle plate is put in

VAPORIZATION OF FUEL

their way, heated by a lamp or by the exhaust; in others, again, the gas is led into a chamber just outside the cylinder, kept hot by a lamp.

Extra Air Valve

There is one special point about these float-feed jets, as they are called. The greater the suction of the engine, the greater is the amount of paraffin taken up. Another way of putting it is that since the suction increases as the speed of the engine increases, the paraffin taken up will also increase with the engine speed. That is why a float feed and jet are self-regulating. As a matter of fact, the amount of paraffin coming out of the jet is usually rather too great at high speeds, and an extra air valve is then fitted on the inlet pipe between the jet and the engine. This valve may be exactly like the one described as fitted on the crankcase of a two-stroke motor; in other words, an ordinary "mushroom" valve with a very weak spring. At low speeds the suction of the engine is not great enough to open it, but at high speeds it is sucked open, and some pure air is taken in and mixed with the excess of paraffin that is in the inlet pipe.

What has been said will show how a vaporizer works and how it can be arranged always to give the right "mixture" without the man in charge having to trouble about it.

Starting from Cold

There is only one point we have not explained. When first starting, the exhaust pipe and vaporizer are cold, and cannot be used to heat the mixture. Either the engine must be started by supplying petrol instead of paraffin to the float chamber and running on it until the engine is hot, or a blow-lamp must be used to heat the vaporizer.

The Petrol Carburetter

The float-feed vaporizer, with its spray jet, as we have seen, depends chiefly on heating of the "gas," and so is rightly called a "vaporizer." Very often one talks of a "paraffin carburetter," but almost always the word "vaporizer" should really be used when paraffin is the fuel. Now, most petrol carburetters have a float chamber and jet of the kind just described, but with petrol no heating of the mixture is necessary before it passes to the engine. Sometime, but not always, air is drawn from near the exhaust pipe to warm it slightly before it passes to the carburetter, but there is no heating of the mixture on its way from the carburetter to the engine.

It is convenient to reserve the word "carburetter" for cases where no heat is used, and since it is possible to start up from cold on petrol, this fuel is often used to heat up a paraffin vaporizer at the start. As has been said, another way is to heat a vaporizer with a blow lamp, and then paraffin can be used at the start without any petrol at all.

Carburetters for Two-stroke Engines

We have explained that in a two-stroke engine gas is first drawn into the crankcase instead of direct into the cylinder, as in a four-stroke engine. The suction in the crankcase is very much weaker than the suction of the cylinder, and so a carburetter that will answer very well on a four-stroke engine may not be suitable for a two-stroke. The float-feed spray jet type, that we have just described, requires very strong suction, and so is best for a four-stroke engine. A carburetter working in the same way is often used for two-stroke engines, but the jet is generally rather larger, and the petrol level in the float chamber is higher, so that a very slight suck is enough to make it flow out. Also, the pipe through which air is drawn is larger than in a four-stroke engine, otherwise the weak suck of the crankcase would not draw enough through. In fact, a two-stroke carburetter must work more easily than a four-stroke one, and it is often called a "free" carburetter for that reason. In either a two-stroke or four-stroke carburetter the jet is sometimes made so that its size can be altered, and this is most often done in the two-stroke kind.

A Simple Carburetter Described

Fig. 4 shows a design of carburetter that is very often used on two-stroke engines. The float chamber (B) is bowl-shaped, and has a cork float (F), which lets in petrol through the needle valve (I). It will be seen that this arrangement is even more like the ball-cock of a cistern than that shown

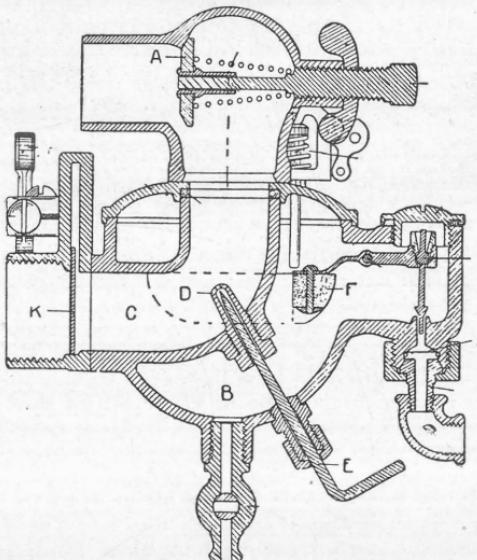


Fig. 4.

VAPORIZATION OF FUEL

in Fig. 2. The inlet pipe (C) through which air is drawn by the suction of the engine is led through the float chamber as shown. Air is drawn in through the valve (A) and passes to the engine through the end (K). There is a shutter here by which the size of the opening (K) can be varied, and which is called a *throttle*. All carburetters are fitted with a throttle, but in order to make everything as simple as possible, we have so far said nothing about them. The throttle is used to control the amount of gas used by the engine, the speed and power being regulated in this way just as a steam engine is regulated by the amount of steam used in the cylinders.

We will now return to Fig. 4. The jet (D) is also inside the float chamber, and is screwed into the inlet pipe (C), so that air passing over it sucks petrol through. There is also a needle valve (E) used to regulate the size of the jet. If the drawing be looked at closely it will be seen that there is room for petrol to flow past the needle to the jet, but that the point of the needle can be screwed right into the small

opening at the top of the jet. This gives us a means of regulating the amount of petrol to suit the needs of the engine. There is also a means of regulating the amount of air to give the best result. The valve (A) is a very weak inlet valve, such as we showed in Fig. 3.

There is always a

small opening at its lower side, enough when the engine is running slowly, but as the speed increases the suck gets stronger and the valve is opened, letting more air through. A butterfly nut will be noticed outside the carburetter on the right of the valve, and by this the strength of the spring can be set to give the best result.

The carburetter just described is one that is actually used, especially on two-stroke engines, and it is one of the simplest there is. There are a very great number of other patterns, but we have not attempted to describe them. Different types are used on almost every engine, but the maker will always show how they work, and after carefully reading what we have said about carburetters and vaporizers, there should be no difficulty in understanding them.

The "Vaporizer Valve."

So far, we have only mentioned the hand-set needle valve (Fig. 1) and the plain jet. There is another form of jet often used on two-stroke engines and illustrated in Fig. 5. Here we have an inlet valve (A) like the one shown in Fig. 3, air being sucked in and passing through the valve as shown

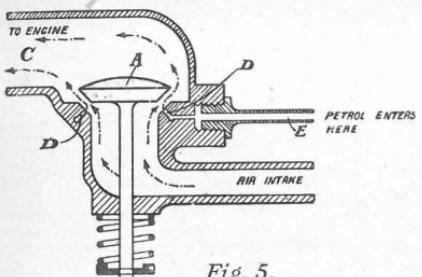


Fig. 5.

by the arrows. It then goes on to the engine through the pipe (C). There is no ordinary jet at all, but very small holes (D, D) are drilled in the valve seating, and petrol is supplied to them by a pipe (E). When the valve (A) is closed no petrol can flow out of the holes (D), but when it is opened the petrol is taken up by the air passing through, being sprayed into a fine cloud. This arrangement, with either a lamp or exhaust heating, is sometimes used with paraffin, and is often called a *vaporizer valve*.

Another Type of Vaporizer

Fig. 6 shows a type of vaporizer that is sometimes used on fishing-boat engines. It is not a copy of any particular make, but gives an idea of the general form that several makes take. We have the cylinder of an ordinary four-stroke engine, the exhaust valve being marked B. On the inlet valve side (A) the cylinder is supposed to be broken away, showing the inside. The inlet valve pocket (C) is enclosed in an outer case (D). A hand-set needle valve (E) supplies paraffin to the inside of the case (D), which really is the vaporizing chamber. Holes (F) allow air to enter the vaporizer. When the engine is running the valve pocket (C) becomes heated by the explosions, and the paraffin

coming from E is vaporized. On the suction stroke the valve (A) opens, and air is sucked through the holes (F), mixing with the hot paraffin vapour and going through the valve (A) to the cylinder. Now, if all the air needed were taken through the holes (F), the vaporizer would be cooled too much, so the holes are only made big enough to let in a little air, just enough to mix with the paraffin. The rest of the air enters the

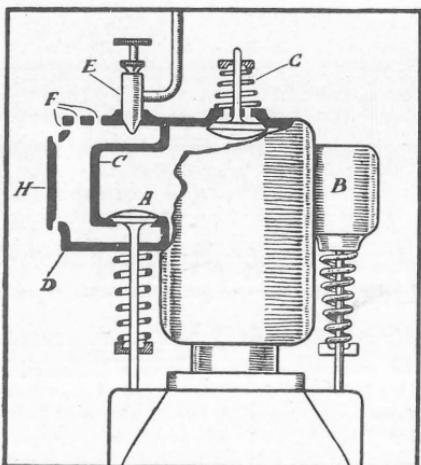


Fig. 6.

cylinders through a separate automatic air valve (G), which works in exactly the same way as the extra air valve we have already mentioned.

When first starting up, the inside of the vaporizer has to be heated by a lamp. A door (H) is fitted for the purpose. This is opened and a blow lamp played on to the wall (C) of the vaporizer for about 10 minutes. If it is necessary to run the engine slowly for a long period, it is advisable to keep a blow-lamp burning.

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Putting Fuel Direct into the Cylinders

It is not difficult to see that paraffin cannot be used in a two-stroke engine in the same way as petrol. Petrol "gas" and air can be drawn into the crankcase and used in the way described, but if paraffin were used in this way it would not remain in the form of vapour while waiting to get through to the cylinder, but would condense into a liquid again and collect in a pool in the bottom of the crank chamber. Therefore, in a two-stroke engine using paraffin, the fuel is generally supplied direct to the cylinder, either by a pump or some other means. Air only is sucked into the crankcase, and there is *no carburetter or vaporizer at all*. Engines of this kind are very simple, and are coming more and more into use, especially when oils heavier than paraffin are used.

A Simple Two-stroke Example

Fig. 7 shows a simple arrangement of this kind. The engine which we illustrate on this page is an ordinary two-stroke, and can be run either on petrol or paraffin, though ordinarily petrol would be used for starting only. It is a two-cylinder motor, and for running on petrol the carburetters, or "vaporizer valves" (A A), are used. If it were a four-stroke engine, one carburetter would do for any number of cylinders, but in a two-stroke engine each cylinder has to have its own part of the crankcase to itself, otherwise no gas could be sucked in. In a two-stroke engine a carburetter is generally fitted

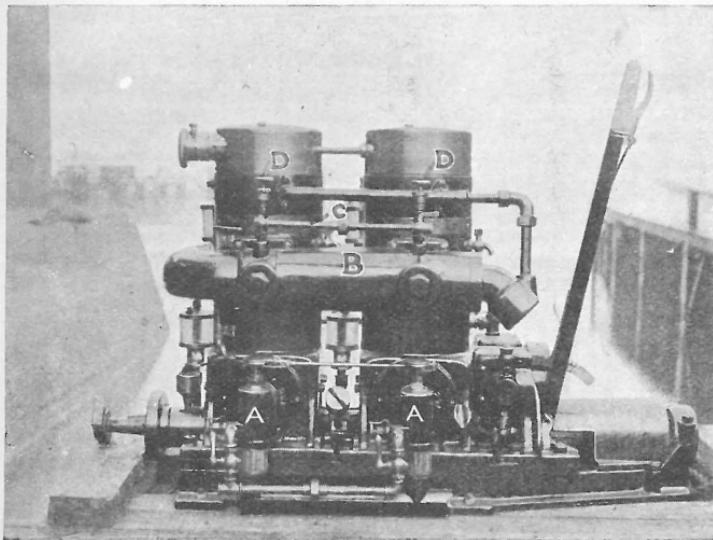


Fig. 7.

to each crankcase division. The exhaust pipe (B) takes the exhaust from both cylinders, and it has a jacket round it. C is the paraffin pipe, fitted with a hand-set needle valve (D) to each cylinder. The paraffin is taken into the exhaust pipe jacket, and then through small openings into the cylinders just above the exhaust ports. Petrol is used for starting up, but after the exhaust has got hot enough the paraffin is turned on. It enters the cylinder, and is then completely vaporized by the heat of the piston. Then the petrol is turned off and air only is taken into the crankcase through the vaporizer valves (A, A). This air then rushes into the cylinder and mixes with the paraffin vapour, so that the gas is made inside the cylinder itself, and there is no outside vaporizer at all.

Oil Pumped into the Cylinder

We now come to another way of supplying fuel direct to the cylinder without the use of any vaporizer, and one which is very often used with engines running on heavy oil, whether two-stroke or four-stroke. It is pumped in through small spraying jets, air enters through separate valves or ports, and the "gas" is mixed in the cylinder. Of course, no outside vaporizer is wanted, but heat must be had somehow, especially at starting, so engines of this kind generally have a bulb on the top of the cylinder which remains red-hot when the engine is running, and which is heated by a blowlamp for starting. The paraffin or heavy

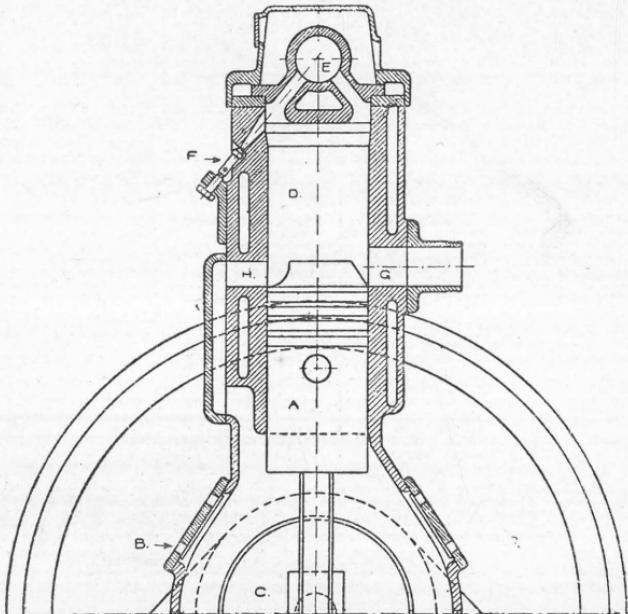


Fig. 8.

VAPORIZATION OF FUEL

oil is pumped straight into this bulb, generally just before completion of the compression stroke, where it is vaporized.

Fig. 8 shows a Bolinders two-stroke engine. This motor runs on heavy oil. The piston (A), with baffle plate on top, is shown at the bottom of its stroke, the inlet port (H) and the exhaust port (G) being both open. Air enters the crankcase through holes (B), which are covered with leather "flap valves" (not shown). E is the hot bulb, surrounded by an outer case to prevent loss of heat. F is the delivery end of an oil pump, which sprays oil straight into the hot bulb (E). The oil comes out in a cloud of vapour at the other side of the bulb, and mixes with the air taken in at H. There is no need to describe the pump itself. It is generally a small plunger pump, working in the same way as an ordinary hand bilge pump, only it is made very small indeed, because only a very little oil is needed. Usually the length of stroke, consequently the amount of fuel injected, is controlled by a hit-and-miss type governor.

Fig. 9 shows the sort of jet or nozzle that is used on one make of engine to squirt oil into the hot bulb vaporizer. The pump delivers oil below and forces or "injects" it through the small valve which is shown with its spring.

Oil Injected by Air Pressure

In addition to the plunger fuel pump, a very high-pressure air pump is used on some engines, the air picking up the oil and forcing it into the hot bulb in a fine spray.

Time at which Oil is Injected

In a four-stroke engine, we know, there is an explosion only every other revolution, so the oil pump has to be

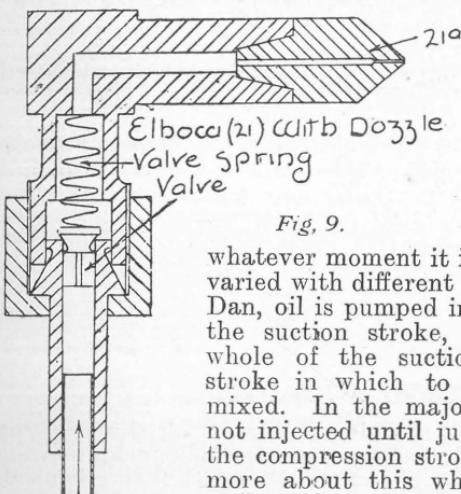


Fig. 9.

geared down two to one, just in the same way as the camshaft. For this reason the oil pump is generally driven off the cam-shaft. The pump can, of course, be set to inject oil at whatever moment it is wanted, and this is varied with different engines. In one, the Dan, oil is pumped in at the beginning of the suction stroke, so that it has the whole of the suction and compression stroke in which to become thoroughly mixed. In the majority of engines it is not injected until just before the end of the compression stroke, but we shall say more about this when we come to describe different makes of engine fully.

CHAPTER III

Hot-bulb Ignition

THE time has now come to show how the charge is exploded. The word "ignition" is always used to express this operation, and though it may come more naturally to say "firing," it is as well to get accustomed to "ignition," for it is used by all motor engineers. *There are two sorts of ignition—hot bulb and electric.*

Hot-bulb ignition is the simpler, and an idea of it was gained at the end of the last chapter. It is used on many heavy-cil, slow-running engines, but for petrol engines and moderate-speed paraffin engines, such as are used in many East Coast fishing boats, some form of electric ignition is most common. It is impossible to say that one system is better than the other. Each has its advantages, as will be seen presently, and perhaps the only objection to electric ignition is that it is rather difficult to understand, and that it is not suitable for heavy oils.

Hot-bulb Ignition

We will deal with hot-bulb ignition first. It consists, as the name implies, of a bulb or tube heated to a dull red heat and bolted to the cylinder head. We had just described such an arrangement in mentioning the Bolinders oil-feed system, in which oil is squirted direct into a hot bulb on the cylinder head. In this case the bulb was used as a vaporizer, but it served also for ignition, and the same sort of bulb can be used equally well for ignition purposes only. Naturally, before an engine can be started the bulb must be heated to redness by means of a blow-lamp, but once the engine is running the lamp can be put out, the heat of the explosion being enough to keep the bulb hot. It is usually necessary to fit a hood or cover over the bulb to enable it to keep its heat, and if an engine is to be run light or with only a little of its power it is generally necessary to start the lamp again, for the weak explosions do not develop enough heat to keep the bulb red hot.

Timing the Explosion

A few engines have a little shutter, which shuts off the hot-bulb from the cylinder, except at the moment when the explosion is wanted, but, as a rule, no such fitting is used. The bulb is left always in communication with the cylinder,

HOT-BULB IGNITION

and the explosion takes place automatically at the right moment.

The Effect of Compression

This brings us to a very important point: the effect of compression. We have seen that, on the compression stroke, the gas is compressed inside the cylinder. In a petrol engine the pressure is about 70 lb. to 85 lb. to the square inch; with paraffin it is rather less, usually 60 lb. to 70 lb. Now, it is a curious fact that the higher the compression the more easily can gas be exploded. The dull red heat of the hot bulb is not enough to explode a charge before it is compressed, but it is just enough to explode it when the full compression is reached. Paraffin and air explode at a lower compression than petrol and air, and that is one reason why paraffin engines have a lower compression than petrol engines. The compression of hot bulb engines varies from 100 to 200 lb. per sq. in.

Effect of Varying Heat of the Bulb

Now, if the bulb is at a bright instead of a dull red heat, it will explode the charge sooner, that is to say, just before the full compression is reached. It might be thought that this would stop the engine and start it running in the opposite direction. This is what is known as a "back-fire," and it does happen occasionally, but not unless the bulb is very much too hot and the engine running very slowly. As a matter of fact, combustion is not absolutely instantaneous; it takes a small fraction of a second. Now, an engine turning at some hundreds of revolutions a minute will only take a small fraction of a second to move from near the end of its compression stroke to just beyond the dead centre. It is, therefore, an advantage for the explosion to commence slightly before the end of the compression stroke, and the faster the engine is running the earlier may be the explosion. As we shall see later, this is allowed for in electric ignition by altering the time of the spark. With a hot bulb all we can do is to obtain a slight variation by heating or cooling the bulb. In practice the bulb can be left to itself within a certain range. The faster the engine runs the hotter the bulb becomes; and, on the other hand, if the engine be slowed down, it will let the bulb cool a little and give a rather later explosion.

How to Tell if the Bulb is at the Right Heat

It is not difficult to tell if the heat of the bulb is correct. If it is too hot the engine will make a heavy thudding noise each time it fires, owing to the shock given to the piston by a too early explosion. If the bulb be not hot enough, the engine will be sluggish and will not develop its full power. The cure in either case is obvious. In the first the cover must be removed from the bulb to allow it to cool, in the second the blow-lamp must be used. Some hot-bulbs are now water-cooled.

CHAPTER IV

Electrical Ignition

WE have now studied the various forms of hot-bulb ignition, so will turn to electric ignition. It consists simply in making an electric spark inside the cylinder at the right moment. This spark is very hot, and so explodes the gas just as the red-hot bulb does. The only difference between the two kinds of ignition is that, since the bulb is always red hot, the gas will explode as soon as it reaches a certain compression, but with electric ignition we can make the spark at any moment we like. That is the great advantage of electricity. We do not have to heat the bulb before we start the engine, and we can make the explosion take place just when we like. When running fast, as we have seen, it is an advantage to fire the gas rather earlier than when running slowly. With a hot bulb we can only do this to a very limited extent, except when the oil is injected into the cylinder at the moment of firing. With electric ignition we can do the same thing with any engine; that is to say, we can vary the speed much more easily, and we have what engineers call a more "flexible" engine.

What is Electricity?

The first question that every man asks is, "What is electricity?" As a matter of fact, no one knows quite what it is, though we do know how to produce it and use it. The easiest way of understanding, however, is to treat it as if it were water. Just as water flows along pipes, so electricity flows along wires, especially copper wires. Water flows through big pipes more easily than through little ones, and in exactly the same way electricity flows more easily through big wires than small ones. Again, we can let water run slowly and quietly through pipes, or we can pump it through at very high pressure. We can have a high-pressure or low-pressure flow of water, and in the same way we can have electricity flowing at high pressure or low pressure.

Water can be made to flow by pumping it, and electricity, like water, may be "pumped" from one place to another.

Electric Batteries

Water can be collected in tanks or reservoirs, and we will now show how electricity may be collected. An electric tank is always called a "battery," or "accumulator."

ELECTRICAL IGNITION

Most readers will know what an ordinary battery used for electric bells in a house looks like. It is a glass jar with a stick of zinc and a stick of carbon in it, and it is filled with salt dissolved in water. The carbon stick is generally put inside a white earthenware pot, but that we need not worry about. Electricity is made, or *generated*, as engineers say, by the salt slowly eating away the zinc. It is what is called a "chemical action," but that, again, need not bother us. The result is that electricity can be drawn off from the carbon stick so long as any zinc is left to be eaten away by the salt. If it were a water tank, we should draw off water from a tap. But electricity, as we have seen, flows through wire, not pipes, so we simply connect a copper wire to the top of the carbon stick and draw off our electricity from it.

We now come to another point. Everyone knows that a beer barrel has a tap at the bottom and a plug at the top, and beer will not run out of the tap unless we loosen the plug at the top to let air in to take its place. In the same way, we cannot get electricity out of the carbon stick of the battery unless we connect another wire to the zinc stick, to let something flow into the battery to take its place.

As has been said, no one knows what electricity is, nor does anyone know what flows into the battery again at the zinc stick. The easiest thing, therefore, is to suppose that electricity simply flows out at the carbon stick and back again at the zinc stick. Now, we have one wire joined to the carbon stick and another to the zinc stick, and, if electricity has to flow from one to the other, the wires must be connected or joined together. This is exactly what has to be done to get a current of electricity. We have to join together the wires of the carbon or zinc sticks. The wires, which can be any length, make what is an "electric circuit," and joining them together is said to "complete the circuit." Separating them "breaks the circuit."

How to get an Electric Spark

Now, if we have water flowing through a pipe, and we cut the pipe in half, water will rush out; in the same way, if we break the electric circuit, electricity will rush out. But there is this difference. The water will go on running, the electricity will not. We have just seen that electricity will only flow when the "circuit is completed," so that when the "circuit is broken" we only get one rush of electricity and the flow stops. This short rush of electricity is an *electric spark*. We can go on "completing" or "making" the circuit and "breaking" it again, and at each "break" we shall get a spark. However gently the electricity is flowing, that is, however low the pressure, we can always get this sort of spark, and it is, therefore, called a "low-pressure," or, more usually, "low-tension" spark. If the two wires from one battery were

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led inside the cylinder of an engine, as shown in Fig. 1, and if we could separate the ends at the moment when an explosion were required—that is, at the beginning of the firing stroke, we should get a spark inside the cylinder,

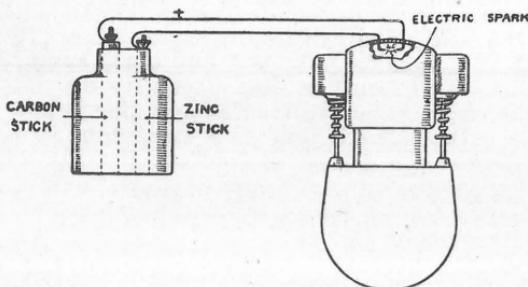


Fig. 1.—Bell battery arranged as if to produce a spark in a cylinder.

and that spark would cause the explosion. All that is wanted is some way of pulling the wires apart at the right moment. That, and many other practical points, we will explain a little later.

Some Electrical Names

Terminal

We have mentioned that wires have to be fastened to the carbon and zinc rods of the battery. For this purpose each stick is provided with a brass screw and nut, which is called a *terminal*. As we shall see later, wires often have to be joined up to different points to make "circuits," and brass screws and nuts, or other kinds of fastenings, are used for this purpose. They are always called *terminals*.

Positive and Negative Terminals

Electricity, we know, flows from the carbon terminal to the zinc terminal of a battery. As we shall see later, carbon and zinc batteries are not the only kind, and so the terminal of a battery from which the current flows is always called the *positive terminal*, the terminal by which the electricity returns to the battery is called the *negative terminal*. These words are used so often that, to save time in writing, "positive terminal" is often written simply "+" or "+ terminal," and "negative terminal" is written "-" or "- terminal." It is always necessary to know which terminal is which, and so it will generally be found that the positive terminal of a battery is marked "+" in red. The end of a wire to be connected to "+" is often painted red.

Battery and Cell

We have already explained what an electric battery is, and we will turn again to the ordinary bell battery. Usually, there is not one jar, but two or three. Each jar is called a *cell*, the whole number connected up together making a *battery*.

ELECTRICAL IGNITION

Volt—the Measure of Pressure

Water pressure is measured in so many pounds to the square inch, and in the same way electric pressure is measured in *volts*. A pressure of one volt corresponds to one pound to the square inch. There is no need to explain how a "volt" is arrived at, but to give an idea of the "size" of a volt, we may say that one cell of a bell battery has a pressure of about $1\frac{1}{2}$ volts.

Ampere—the Measure of Flow

The amount of flow of water is spoken of as so many gallons a minute. What corresponds to one gallon of water a minute is called in electricity an *ampere*.

Ohm—the Measure of Resistance

A small or very long pipe offers a lot of resistance to the flow of water, and in the same way a small or very long wire offers a lot of resistance to electricity. The measure of electrical resistance is called an *ohm*, and is the resistance of about 100 yards of telegraph wire.

Connection between Volt, Ampere, and Ohm

These three electrical measures are closely related. If we take a certain length of pipe, and use it to drain a water tank, the greater the size of pipe the quicker will the tank be emptied. That is, the less the resistance the greater the rate of flow. It is the same with electricity. A pressure of one "volt" acting against a resistance of one "ohm" will allow a current of one ampere to flow. If the resistance is doubled, that is, two ohms, the current will be halved, that is, only half an ampere. Again, if the resistance be kept at one ohm, and the pressure be raised to two volts, the current will be two amperes, and so on.

Pressure or Voltage of a Battery

Anyone who has seen an electric bell battery will have noticed that it is made up of two or three "cells." The

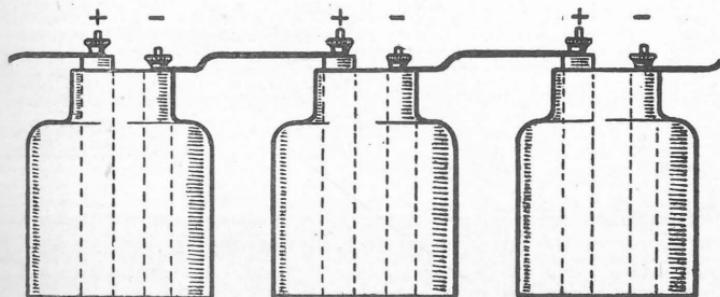


Fig. 2.—Press bell batteries in series.

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object of using several cells is to increase the electric pressure, that is "voltage," of the battery. It will be found that the zinc of one cell is connected to the carbon of the next, and so on (Fig. 2). This is what is called connecting cells *in series*. The effect (we need not explain why) is to raise the pressure, and the actual pressure of the whole battery is always the voltage of one cell multiplied by the number of cells. In our figure we will suppose that each cell has a pressure of one volt. There are three cells, so the pressure of the whole battery will be $1 \times 3 = 3$ volts. It will be noticed that this way of connecting a battery leaves one + and one - terminal vacant at each end, and these are the only ones that will be used for making a circuit. For boat work it will generally be found that a battery is made up with only two terminals, showing however many cells there may be, so that a battery may always be treated as a single cell.

Insulation—Conductors and Non-conductors

In laying water pipes we have to take care not to have any leaks, and in the same way leakage from wires carrying electricity must be prevented. Electricity flows through copper more easily than any other metal, and that is why it is used for wires, but it can flow through any metal. Anything through which electricity can flow is called a *conductor* of electricity, and all metals, especially copper, are said to be "good conductors." Many liquids, such as water, will allow electricity to flow through them, but not nearly so easily as it can through metal, and water, therefore, is called a *bad conductor*. Lastly, such material as cotton, silk, and, above all, indiarubber, china, glass and mica will not allow electricity to flow through them at all, and they are called *non-conductors* or *insulators*.

Now, if we were to let a bare copper wire through which electricity was flowing touch metal or any other conductor, some electricity would be lost, so we *insulate* the wire by wrapping it up in indiarubber and cotton or silk. In the same way, any terminal to which a wire is connected is insulated from everything except the point to which it is desired to lead the electricity.

Accumulators

We now know enough about electricity to be able to understand the various ways in which it is actually used for ignition in an oil engine. We will first of all describe the form of battery generally used. It is rather different to an electric bell battery, and is called an *accumulator*. In the bell battery, as we have seen, zinc is eaten away to make the electricity. In an accumulator nothing is eaten away. Electricity is—as it were—poured into the accumulator just as water is poured into a tank. When the electricity has been used up, more is poured in, and so an accumulator can

ELECTRICAL IGNITION

be used over and over again. We will say more about this later, when we come to the care and upkeep of oil engines.

An accumulator is made up of lead plates or grids, on which are fastened certain kinds of red lead. In each cell are a number of “+” plates, all connected together, and a number of “-” plates, also connected together. There is thus only one “+” and one “-” terminal to each cell. The cell is filled with a mixture of sulphuric acid and water. Accumulators are nearly always sold as batteries of two cells each. When new they have no electricity in them, and have to be *charged*. Charging consists of passing a current through the battery, the + terminal of the source of supply being connected to the + of the accumulator, so that current is sent through it in the reverse direction to that in which it is given out. “Charging” usually takes 8 to 10 hours. When charged a cell has a pressure of about $2\frac{1}{4}$ volts, or $4\frac{1}{2}$ volts for a two-cell battery.

After being charged, an accumulator will supply current until the whole store is used up, the pressure gradually falling to just under 4 volts, and about as much electricity can be got out of a battery as was put into it. When “empty” the battery must be “recharged,” and then used again, and so on.

It is most important that a battery should not be charged or discharged too quickly. There is always a label on the outside of each battery giving its “capacity.” If the “capacity” is said to be 20 ampere hours, it means that the battery can supply a current of one ampere for 20 hours or two amperes for 10 hours, etc. It is a safe rule never to put into or take out of a battery a current that will charge or discharge it in less than 10 hours. For example, a 20-ampere-hour battery should never give or receive a greater current than two amperes, or a 40-ampere-hour battery more than four amperes. There are instruments called “voltmeters” and “amperemeters” for measuring volts and amperes, but, as a rule, it will only be the voltmeter that the motor engineer will use, and that only to see if his battery needs charging. He will nearly always get his



Fig. 3.—A four-volt accumulator.

charging done at a boat yard, and as the "gadgets" used with electric ignition are designed not to take too much current he need not trouble about the rate of discharge. There is only one thing to be careful of. *Never let a piece of wire or any bit of metal, such as a spanner, be placed across the terminals of an accumulator, for by so doing the battery would be rapidly discharged, and the sudden rush of current would probably spoil it altogether.* Fig. 3 shows an ordinary four-volt accumulator, such as is used on a boat.

Electric Coils or Solenoids

We now come to an arrangement that is not very much used in practice, but which is still of some practical use, and which helps greatly towards understanding the more com-

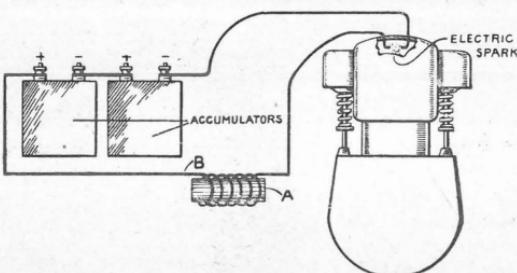


Fig. 4.—Ignition by 8-volt battery and solenoid.

mon forms of ignition. We refer to what is called a *solenoid*. The ordinary accumulator, it must be explained, if used exactly as shown in Fig. 1, would not give a hot enough spark to produce an explosion unless a very much heavier current were taken from it than is good for it. What is done, therefore, is to connect two four-volt batteries together, making up an eight-volt battery, which is used with a "solenoid," as shown in Fig. 4.

Making and Breaking Contact

"Solenoid" sounds a very imposing word, but it is really a very simple thing. It consists of a bundle of soft iron wires (A, Fig. 4), with a coil of insulated copper wire (B) wound round it as shown. This coil is connected between the accumulator and the motor as shown. There is no need to explain why it acts as it does; to do so would mean writing a book as big as this Handbook now is, but its effect is to give a very much stronger current at the moment the circuit is broken, and, instead of a feeble spark in the cylinder, we get an intensely hot flame that is perfectly certain to fire the charge. The great advantage of the "solenoid" is that it gives this extra current without taking any extra electricity out of the accumulator.

ELECTRICAL IGNITION

Breaking Contact in the Cylinder

It must now be shown how the circuit is actually broken in the cylinder. It is quite clear that the simple arrangement shown in Figs. 1 and 4 will not do, for the wires would be blown out of their holes and allow gas to escape, also it is not possible to have a hand inside the cylinder and to pull the ends of the wires apart.

Earth connection.—The trouble is half got over by doing

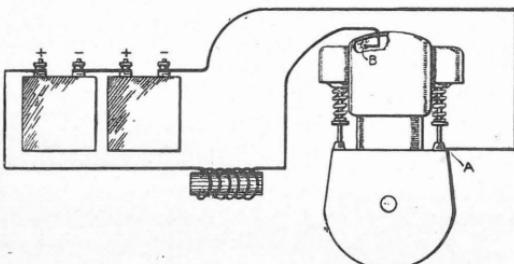


Fig. 5.—Eight-volt battery and solenoid using "earth" return.

away with one wire altogether. The whole engine is made of metal, so we can arrange to use it to conduct electricity, as shown in Fig. 5. Here we have the same arrangement as in Fig. 4, but the — wire from the battery, instead of being taken inside the cylinder, is fastened to any convenient nut or bolt on the engine, as at the point A. The other wire, insulated of course, is carried through the cylinder as before, but we can now break our contact against the cylinder wall at the point B. Now the engine itself is bolted to the boat, and the boat is in the water, which, as we have seen, is a "bad" or partial conductor of electricity, so that the — terminal of the accumulator is connected to the sea or the "earth." The arrangement is therefore called an *earth connection*.

The contact breaker.—All we have to do now is to arrange a practical way of making and breaking contact between the remaining wire and the cylinder. There are naturally several ways in which this can be done, but we will only describe one very simple form of "make-and-break" or "trip" gear as it is called. It is necessary first of all to carry a rod carefully insulated through the cylinder, and, secondly, to arrange a little rocker, also carried through the cylinder, to make and break contact with the insulated rod. The rocker will have one arm inside the cylinder for this purpose, but the other arm must be outside. The outer end of the insulated rod is connected to the solenoid, as in Fig. 5, and since the rocker is touching the cylinder itself, it will be seen that when the inside arm of the rocker touches the insulated rod the circuit is "made." When the arm is pulled away from it the circuit is broken and we get a spark.

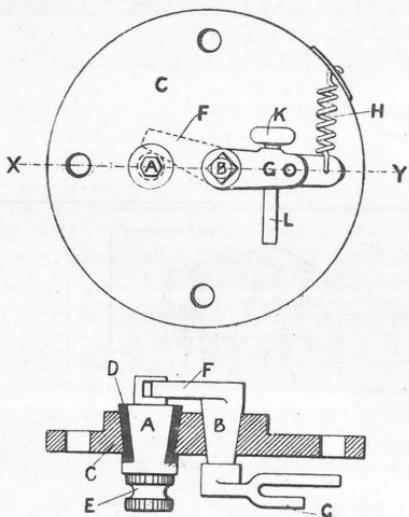


Fig. 6.—Trip gear for making and breaking contact in the cylinder,

it from above. It will be noticed that A and B are both tapered, so that the force of the explosion, trying to blow them out, will jamb them hard into the plate and make a perfectly tight joint. Insulation, in this case made of mica (marked D), is shown black. The terminal (E) outside the cylinder would be connected to the solenoid. The inside arm (F) of the rocker can touch the end of the rod (A), as shown; the outer arm of the rocker (G) is forked. A spring (H) hooked on to the end of G keeps F in contact with A, so that to break the circuit and get a spark we have to pull G down against the spring.

This is done by the head (K) of the rod or "tappet" (L). This tappet works exactly like the valve of a four-stroke motor. It is held down by a very strong spring (not shown), much stronger than the spring (H). The bottom of the tappet (L) can be raised by a "cam," also exactly like an inlet or exhaust-valve cam. Now, so long as L is held down by its own spring contact inside the cylinder is broken, but directly L is lifted by its cam, the spring (H) pulls the outside arm of the rocker and contact is made inside the cylinder. *Directly the cam releases the tappet (L), the arm (G) is pulled down and a spark is made inside the cylinder.* We see then that the spark is made, not when the cam first lifts the tappet, but when it lets it drop again. Lifting the tappet makes the contact and allows current to flow just long enough to get a spark, when the circuit is broken again. In this way a great deal of electric current is saved. In a four-stroke engine a

Fig. 6 shows how this may be done. The insulated rod (A) and the rocker (B) are both fitted in a plate (C), which is bolted to the side of cylinder. A great advantage of this is that if anything goes wrong with the gear it can be taken right away from the engine and put right. In the upper part of the drawing we are supposed to be looking at the "trip" gear from the side; in the lower part the plate (C) is supposed to be "sectioned," or cut in half through the dotted line (X Y) of the upper drawing, so that we look down on

ELECTRICAL IGNITION

spark is only wanted one in every two revolutions, so it would be useless to be using the current all the time.

The Case of the Multi-cylinder Engine

We have now shown how low-tension ignition can be used with a single cylinder. If we liked, we could fit exactly the same arrangement to each cylinder of an engine having two, four or any other number of cylinders. But there is a much simpler way than that. We can use one accumulator and one solenoid for any number of cylinders. Fig. 7 is a sketch of a four-cylinder engine. Each cylinder has the plug and tappet arrangement or "trip gear" just described. We have an accumulator (B) with its - terminal "earthed" at E, and its + terminal going to the solenoid (C). The other end of C is connected to a wire or rod running all along the engine, with branch connections to the insulated terminal of each cylinder. Electricity will flow from the accumulator through C to D and back through whichever cylinder a contact is made by the trip gear. This gives us another reason for only making contact in a cylinder just before the spark is required. If contact were always made in all four cylinders, we should get no spark by breaking one contact. The electricity would simply flow quietly through the other three.

Timing the ignition.—We have said that one of the advantages of electric ignition is that the moment of sparking can be altered to suit exactly the speed of the engine. We know that ignition must take place at about the beginning of the firing stroke, and so we simply set the "cam" of our "trip gear" in such a position that the tappet will be released as the piston begins to descend. There are several ways in which we can get the slight variation in timing that is required. Fig. 8 shows one arrangement, in which the tappet is hinged near its lower end so that it can be moved across the cam. The camshaft (A) is supposed to be turning in the direction shown. The cam has just raised the tappet, allowing contact to be made in the cylinder, but it is about to release it, breaking the contact and producing the spark. We will suppose the cam to be so set that this spark takes place exactly at the top of the stroke. If we want to run the engine faster we must lift and also release the tappet earlier, which is done simply by swinging it over to the position shown by the dotted line. This is called "advancing the ignition." To "retard" the

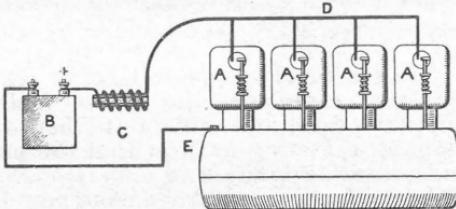


Fig. 7.—Accumulator and solenoid connected to four-cylinder engine.

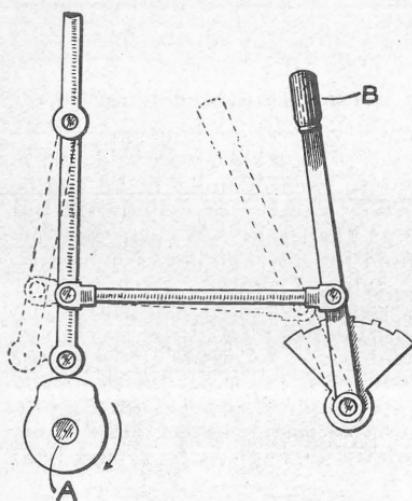


Fig. 8.—Advance and retard gear.

ways of advancing and retarding ignition, one being to cut the cams on the skew and move the whole camshaft fore and aft. But there is no need to explain all these ways. Now that the principle of advancing and retarding ignition is understood, the way in which it is done on any particular engine may be seen at once. By the way, it will be found that the ignition is permanently set on some engines so that it is always in a fixed position and cannot be advanced or retarded.

High-tension Ignition

We now come to a different kind of ignition, called "high-tension ignition," because high-pressure, instead of low-pressure, electricity is used. Instead of getting a spark by breaking a circuit, we have a break always in the circuit, but we use such high electric pressure that sparks jump across the gap. Once again the case of the water pipe will help us. Suppose we take a fire hose and let it squirt water a short distance into the mouth of a pipe similar to the water main from which the hose is supplied, we still get a flow of water through from one main to the other, but the pressure is so high that we can have a gap in the pipe, across which water is squirted, as shown in Fig. 1.

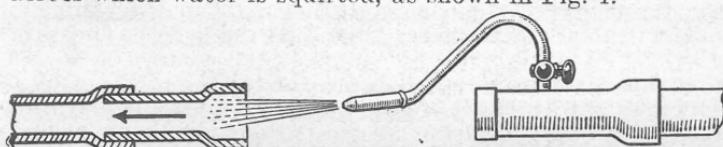


Fig. 1.—The water equivalent of high-tension electricity.

ignition, as we must do at starting, or if we want to run slowly, the tappet would be swung to the other side.

To move the tappet in this way we should want some sort of lever such as that shown. The hand lever (B) works in three notches, and is connected by a rod to the tappet. To advance the ignition it will be moved to the position shown by the dotted line; to retard, it would be moved over to the extreme right-hand notch.

There are other

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Exactly the same thing can be done with electricity. We can use a high-pressure or high-tension current, and let it "squirt" or "spark" across a gap in the circuit. As with low-tension ignition, the spark must take place inside the cylinder, but we have not to make and break the circuit; it is always broken, so that we can do away altogether with the trip gear we have just described. It looks, therefore, as if high-tension ignition should be much simpler than low-tension, and in a way it is, but the great drawback to it for rough work at sea is that the high-pressure current leaks so very easily. Low-tension terminals and wires will stand a good deal of splashing from water, but a very little spray is enough to upset high-tension ignition. When high-tension ignition is used, the greatest care must be taken to keep all wires and all other parts dry.

The Sparking Plug

With high-tension ignition, as with low-tension, we can use the engine itself as one "wire," that is, as an "earth return." All we have to do, therefore, is to lead a very well-insulated rod or wire into the cylinder, and let it spark against the cylinder itself. For this purpose a "sparking plug" is used (see Fig. 2). There is a central rod (A), with a terminal at its top, to which high-tension current is supplied. It is insulated by porcelain (china) or mica (B), and outside this insulation is a steel nut (C), which is screwed into the cylinder. On the end of this nut is a short projecting piece (D), which is brought close to the end of A, as shown. This gap, called the "spark gap," is quite small, about wide enough to take one's thumb nail,

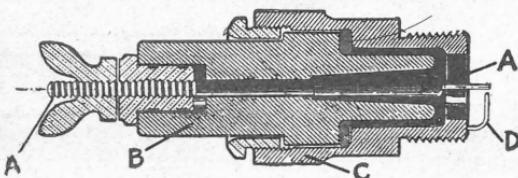


Fig. 2.—The parts of a sparking plug

and it is across this gap that the spark passes. It will be seen that the result is exactly the same as if the spark went from A to the cylinder itself, for the nut (C), being screwed direct into the cylinder, the piece D is, therefore, in contact with the cylinder, and so forms the "earth return."

How High-tension Current is made: The Induction Coil

We now have to show how high-tension electricity is obtained. The pressure required to make even a short spark, such as is wanted to jump across the parts of a sparking

plug, is enormous ; it may be as much as 10,000 volts. To obtain this we should want a battery of accumulators containing 5000 cells, which, of course, would be quite out of the question. But, fortunately, the "solenoid" which we used to increase the current with low-tension ignition can be made to help us, so that we need only use a two-cell or four-volt battery.

A solenoid, it will be remembered, consists of a bundle of iron wires, with a coil of insulated copper wire wrapped round it. Now, there is a very curious point about a coil of this sort, which we will not try to explain, for to do so would take too long. *If we wrap another coil outside the first one, and break a current passing through the first, a current will pass through the second at the moment the break takes place.* There need, however, be no contact between the two coils.

Fig. 3 will help to make the matter clear. An accumulator (A) has one terminal connected to the terminal (B) of a solenoid. The other terminal of the accumulator is connected to a metal spring (C), the other end of which is just over the other solenoid terminal (D).

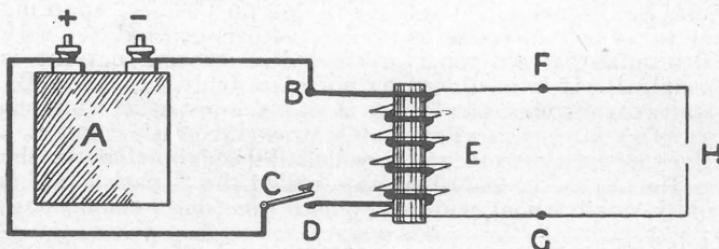


Fig. 3.—Accumulator connected to induction coil.

On top of the first coil of the solenoid is wound another, marked E. To the terminals (F and G) of this coil wires are connected, their other ends being brought close together, but not quite touching, as shown at H. Now, if we press down C into contact with the solenoid terminal (D), the circuit is completed, and current flows through it. If we release C, the circuit is broken, and at that moment we shall see a spark appear at H. As we have said, we will not try to explain why this happens ; it is enough for us to know that it is so. *Whenever we break contact (that is, interrupt the current) in the first coil, we get a spark from the second.*

The current in the second coil is not continuous, it is only just one flash at the moment of breaking the circuit, but it lasts long enough to explode a charge of gas in a cylinder.

This double solenoid is always called an *induction coil*. The first coil is the *primary*, and the second coil the *secondary*.

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It will be asked why the electricity in the secondary should be at high enough pressure to produce a spark. *The pressure depends entirely upon the number of turns of wire in the two coils.* If there are 10 times the number in the secondary than there are in the primary, we shall get 10 times the voltage; that is, if four volts are supplied to the primary, the secondary will give 40 volts. Now, we have seen that about 10,000 volts are wanted for high-tension ignition. Therefore, if there are 100 turns in the primary, there must be $\frac{100 \times 10,000}{4} = 250,000$, in the

secondary. To get such an enormous number of turns a very fine wire has to be used, which would be broken very easily. Consequently, an induction coil is always buried in paraffin wax, together with what is called a "condenser," which is a thing we need not trouble about, and the whole put in a strong wooden box, with only terminals outside.

Contact Makers

To use an induction coil for ignition purposes, the contact between C and D has to be made by the engine and broken again just when the spark is required. This is done by what is called a *contact maker*, an idea of which may be had from Fig. 4. The arrangement is the same as Fig. 3,

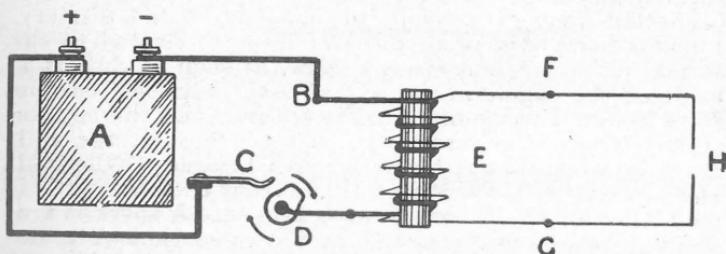


Fig. 4.—Accumulator and coil with engine-driven contact maker.

but the spring (C) is now insulated and mounted on the engine, and the terminal (D) is connected to a special cam on the engine camshaft. As the engine turns, the cam (D) comes in contact with C, and completes the circuit. In our sketch it has just left C, thus breaking contact and producing a spark at H.

Trembler Coils

This was the first kind of high-tension ignition used, but a slight variation of it is now generally used, what is called a "trembler induction coil," or simply "trembler coil," being substituted. In this we still keep the "contact maker," or "commutator," as it is often called, on the engine, but put an extra fitting on the coil. The plain

contact breaker on the engine only gives one spark at the secondary coil terminals. It is considered better sometimes to have a quick succession of sparks in the cylinder, so we fit what is called a *trembler* to the coil, which makes and breaks contact many times a second, each break producing a spark. This trembler begins to work directly contact is made on the engine "commutator." To explain how it works, it must be mentioned that the bundle of iron wires become magnetized as soon as electricity flows through the coil, and demagnetized again as soon as the current ceases. The principle of the trembler is exactly the same as that of an electric bell, and is shown in Fig. 5.

We have the top of an induction coil box, with the ends of the bundle of wires (A) showing. Above them is a flat steel spring (C) corresponding to the spring (C) shown in Fig. 3, fastened down at one end (E), which would be connected to an accumulator terminal. The other end of the spring is in contact with the end (D) of a set-screw, which is connected inside the coil to one end of the primary. Finally, there is a small piece of iron (F) riveted to the spring in the position shown. Now, as soon as contact is made on the engine in the way already described, current flows from the accumulator to the terminal (E), through the spring (C) to the screw (D), and so through the coil. Directly this happens the iron wires become magnetized, and attract the piece of iron (F), so that the spring (C) is pulled down and the contact at D broken. A spark is produced in the secondary, and at the same time A is demagnetized, so that the spring (C) flies up again, and again makes contact with D. Directly this happens the current again flows, C is attracted downwards, and another spark produced. This will continue so long as the commutator on the engine makes contact.

The trembler making contact many hundred times a second makes a buzzing sound, and has to be set very carefully by means of a set-screw. The higher and louder the buzz the better. At the point of contact between the spring (C) and the set-screw (D) there is always wear and a slight amount of sparking going on, which would soon burn steel away. Small platinum points are therefore always fitted, as they do not burn. These points have to be filed square and cleaned occasionally, and when this is done the set-screw (D) has to be set by hand. A very little practice will enable anyone to tell by the tone of the buzz when the setting is right.

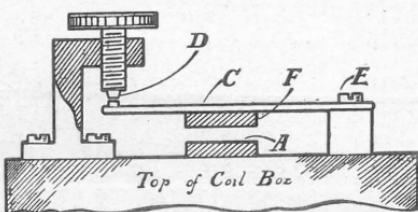


Fig. 5.—Trembler contact of induction coil.

magnetized as soon as electricity flows through the coil, and demagnetized again as soon as the current ceases. The principle of the trembler is exactly the same as that of an electric bell, and is shown in Fig. 5.

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In practice, earth connections are made use of to simplify the wiring, and an ordinary switch such as is used for electric light is also fitted, so that the current can be cut off to stop the engine. Also all coil connections are made inside the box and brought to terminals on the outside of it.

The Wiring of a Single-cylinder Engine

Making the necessary connections is called "wiring" an engine, and now that we understand the various parts of a high-tension circuit we can see how they are used in practice.

Fig. 6 will make all clear. A is the accumulator, B the induction coil. The coil has three terminals, one usually marked P being for connection to the "+" or positive battery terminal. Another coil terminal marked M is connected to the insulated spring (C) of the commutator on the engine (shown on a much enlarged scale). Now instead of

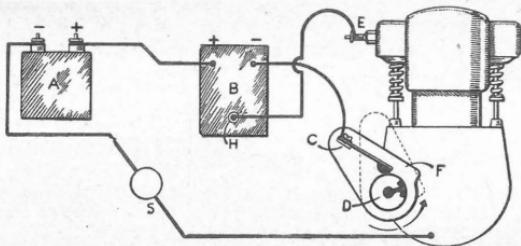


Fig. 6.—Accumulator and coil with all connections to engine.

the cam shown in Fig. 4, a "wipe" contact is often employed. This (marked D) consists of a fibre disc, which is an insulator, mounted on the end of the engine camshaft. In it there is a small metal segment, shown black, which runs through to the centre of the disc, and is therefore connected to "earth," or the engine crankcase. Whenever the metal segment on this disc passes under the end of the spring (C) the M terminal of the coil is joined to earth. Inside one end of the secondary is connected to M, so this also is earthed. The other coil terminal (H) is the other end of the secondary winding, and is connected to the sparking plug (E), as already explained. The "—" accumulator terminal is connected to the engine, that is to earth, through an ordinary switch (S). If these connections are followed, it will be seen that every time the circuit is completed at the commutator, the trembler of the coil is started and sparks are produced inside the cylinder by means of the plug (E). All we have to do, therefore, is to set D on the camshaft in such a position that it makes contact with C at the moment an explosion is required.

Advance and retard of the ignition is very easily arranged. The whole commutator is enclosed in a case (F)

which is mounted on a boss on the engine crankcase, so that the whole case can rock backwards and forwards. If the disc be turning in the direction shown by the arrow, and the case (F) be moved to the position shown by the dotted line, it is clear that C and D will make contact earlier, that is to say, the ignition will be advanced.

Ignition on Multi-cylinder Engines

The same arrangement, with very little extra complication, can be used for any number of cylinders. Fig. 7

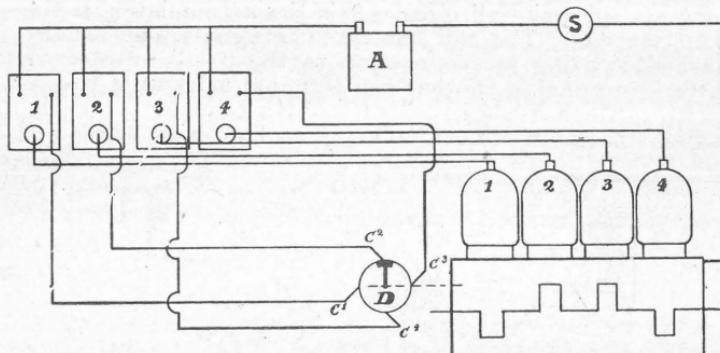


Fig. 7.—Electrical connections for a four-cylinder engine.

shows the case of a four-cylinder motor. There is only one accumulator (A), one switch (S), and one "earth" connection as before. The disc (D) of the commutator is also the same, but instead of one spring (C) there are four, as shown, and there are also four coils. The accumulator is very simply connected to the + of each coil, and each of the springs (C) is connected to an M coil terminal. It will be seen that coils 1, 2, 3, 4 have their high-tension terminals connected to cylinders 1, 2, 3, 4. Now, as D rotates, it is clear that current will flow through each spring in rotation. If we start from the one on the left, current will flow through them in the order 1, 2, 3, 4. Now we know that a four-cylinder four-stroke motor fires either in the order 1, 2, 4, 3 or 1, 3, 4, 2. We suppose the order in this case is 1, 2, 4, 3, and in consequence we connect springs 1 and 2 to the M terminals of coils 1 and 2. But cylinder 4, to which coil 4 is connected, is the next to fire, so we must connect spring 3 to coil 4, and, lastly, spring 4 to coil 3. In the figure, cylinder 2 is shown firing.

Commutators and coils actually used differ naturally from the rough sketches given. Fig. 8 shows a set of four coils mounted together in a box. In this case all the P terminals have been brought to one common terminal at the top left-hand end to make the wiring easier. The other four upper terminals are the M terminals, and at the

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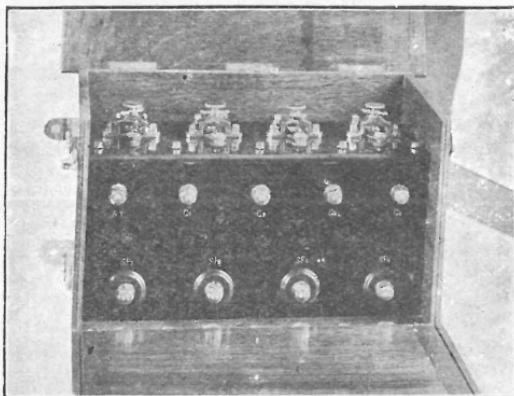


Fig. 8.—Four induction coils mounted together. The top left hand terminal is the common + connection. The H.T. terminals are below.

bottom are the four secondary or high-tension terminals. On top of the coils can be seen the four tremblers.

Fig. 9 shows a practical form of four-cylinder commutator. The springs, so far referred to as C, are replaced by brass segments set inside a fibre ring, outside which can be seen the four terminals for connection to the coils.

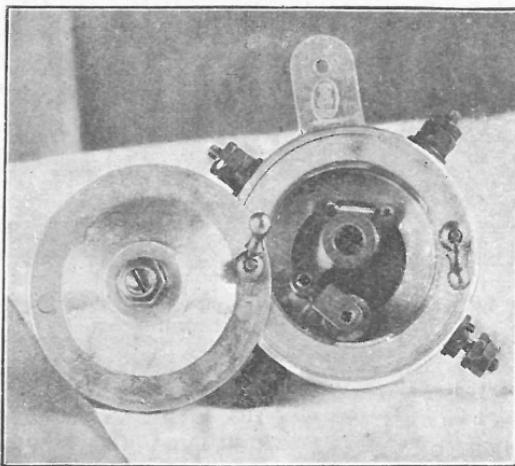


Fig. 9.—Commutator for four-cylinder engine.

Instead of the cam or disc mounted on the camshaft, the earth connection takes the form of a little metal roller held against the ring by a spring. On the left is shown a small cover that fits over the commutator and keeps it clean and dry.

High-tension Distributors

There is still another way of wiring up a multi-cylinder engine in which only one coil is used. We will take the case of a four-cylinder four-stroke engine. Here the four commutator contacts are all connected to the M terminal of the same coil, and, as the commutator is still turning at camshaft speed, there will be four contacts in every two revolutions, that is four sparks will be produced every two revolutions, which is the number wanted in a four-cylinder four-stroke engine. All these sparks will come from the single high-tension terminal of the coil, and this high-tension current must be distributed among the four cylinders. The arrangement for so doing is therefore called a *high-tension distributor*.

In practice the low-tension commutator and the high-tension distributor are made together and driven together off the camshaft. Further, to avoid the need for four connections to the M of the coil, there is usually a single spring in the commutator and four cams or wipe contacts on the camshaft, an extension of the arrangement shown in Fig. 4.

The high-tension distributor is a very simple affair, and the whole arrangement can be seen in Fig. 10. Here is the camshaft (A) carrying the fibre disc (B) and four metal segments. The spring now takes the form of a metal roller (D), and the terminal (C) is connected to the M terminal of the coil. The whole is protected by the fibre or vulcanite case (K), mounted as shown on the camshaft bearing boss. On the extreme end of the camshaft is a fibre disc (E)

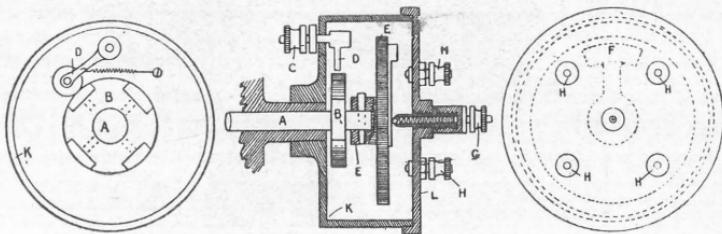


Fig. 10.—Diagram of high-tension distributor, combined with low-tension commutator.

carrying a metal segment (F). The lid (L) of the case (K) has a centre contact (G) connected to the high-tension coil terminal, which transmits the high-tension current to F. Also fixed to the lid (see right-hand illustration) are four terminals (H) connected each to a sparking plug. As E rotates with the camshaft the metal segment (F) touches each of the high-tension terminals in turn and so distributes current to the sparking plugs. To vary the timing, the whole box (K) and its lid (L) is rocked backwards and forwards in the way already explained, so that both the low-tension commutator and high-tension distributor are advanced or retarded together. We have now shown how

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both low-tension and high-tension electric ignition work. The chapter contains many new ideas for those who have had no previous knowledge of electricity, but it is worth while reading it two or three times over if one has to look after an engine fitted with any sort of electric ignition. It is the most difficult part of an engine to understand, and usually requires the most looking after, so time given to studying electricity will be well spent.

Magneto Ignition

The reader is now supposed thoroughly to understand battery ignition, and we come next to magneto ignition. The magneto is simply a machine that produces electricity and so takes the place of a battery. Further, the magneto, being a kind of rotary induction coil, does away with the need for a coil of the sort we have described. Lastly, the make-and-break arrangement and the high-tension distributor, if used, are included in the magneto. The advantages of a magneto, therefore, are clear. In the first place there is no trouble with battery charging; secondly, there are no extra parts to look after beyond the magneto itself, and the only wires leading from the magneto terminals are those to the plugs.

What is a Magneto?

We will not attempt fully to describe how a magneto is made; to understand it properly, one has to be an electrical engineer. Fortunately, however, there is no need to know much about the matter, for magnetos are so beautifully made that they scarcely ever go wrong. They will

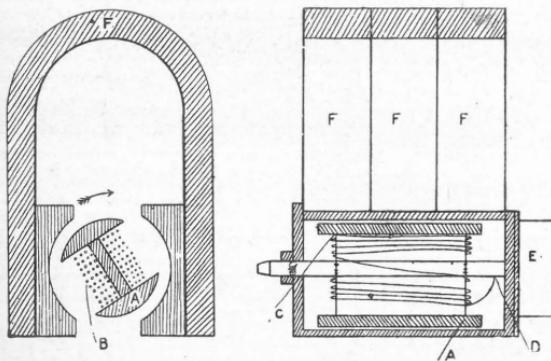


Fig. 1.—A simple magneto showing armature and winding.

run for years with nothing beyond contact adjustments being necessary, and in the very unlikely event of anything else going wrong the best thing to do is to send the machine to an expert, or best of all to the makers.

It has already been said that the passing of current through a solenoid magnetizes the bundle of wires that form its core. The opposite of this is also true. If we could rapidly magnetize and demagnetize the iron core we should produce currents of electricity in the coil. This we, cannot do very well, but we can produce the same effect by using a permanent magneto in place of the iron wires and taking it rapidly in and out of the coil. That, very roughly, is the principle of a magneto.

Low-tension Magneto Ignition

In practice it is easier to keep the magnet still and move the coil, which comes to exactly the same thing. Further, it is much easier to mount the coil on a spindle and rotate it instead of pushing it backwards and forwards. This brings us to the actual form of a magneto, which is sketched in Fig. 1. We have a horseshoe magnet (F) (or rather three of them placed side by side), just like the ordinary magnets that children play with, only much bigger and more powerful, being in this case about 6 ins. high. At the ends pieces are bolted on to make a circular opening, as shown in the left-hand part of the drawing. Brass plates are fitted at either side (see right-hand part of drawing), which form bearings for a spindle and a core of iron (A) shaped as shown. A single coil (B) is wound on this core (see Fig. 1), and the whole of this coil and core, which is called the "armature," is driven by cog-wheels off the engine. There is a ring (E) at one end of the armature, connected to the coil, from which the current generated is collected. One end of the coil is "earthed," and the other, through the ring and a rubbing contact, is connected to the insulated plugs on the cylinders. Fig. 2 shows how simple the arrangement is. The magneto is shown on the left, current is taken from the armature at A and led to the low-tension plugs (C). The rest of the work is done by the ordinary "trip" gear used with low-tension electric ignition. Low-tension magneto, it will be seen, is the simplest form of ignition we can have, for only one wire is used, the magneto entirely replacing the battery and solenoid. A magneto of this sort will run for years with no attention whatever, except for

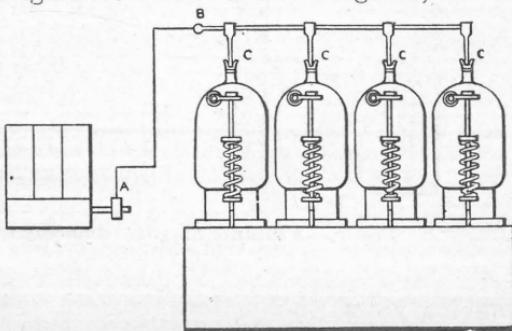


Fig. 2.—Low-tension magneto connected to four-cylinder engine.

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a drop or two of oil in the armature bearings every now and then. Many people use ordinary engine oil for magneto bearings, but it is not good practice to do so, as it is too thick and is liable to clog. Either castor oil or sewing-machine oil will give much better results, and should always be used.

High-tension Magneto Ignition

High-tension magnetos are the same in principle as the low-tension type, but the armature has two windings, a primary and a secondary, but as an induction coil instead

of a "solenoid" is used for high-tension battery ignition. One end of the primary is "earthing" by connection to the armature spindle, the other is connected to a commutator exactly similar to the ordinary low-tension commutator already described. The circuit is broken at the moment that a spark is required, and the act of breaking the circuit produces a high-tension spark in the secondary. This spark is distributed to the cylinders by a high-tension distributor, also mounted on the magneto and driven by gearing off the armature.

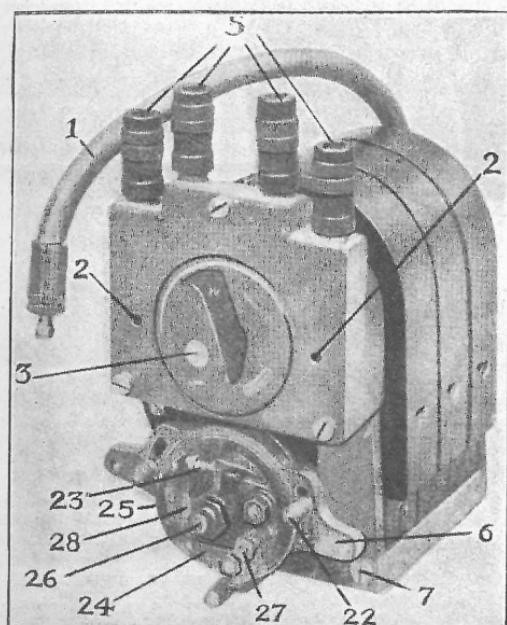


Fig. 3—A high-tension magneto, showing contact-breaker and high-tension distributor.

tension spark in the secondary. This spark is distributed to the cylinders by a high-tension distributor, also mounted on the magneto and driven by gearing off the armature.

An Example

In Figs. 3 and 4 is shown an actual magneto—the "Eisemann"—with its parts numbered. It is intended for a four-cylinder engine. In Fig. 3 can be seen a metal cap and nut (26), to which the insulated end of the armature primary is connected. From here the current is led to the platinum make-and-break contact (23), which in the ordinary way makes contact with an "earth" connection. The other

end of the primary being also earthed, all current generated simply rushes round the coil until the circuit is broken at the point (23) by means of a cam, which, however, is not visible in the illustration. It will be noted that the contact breaker is mounted on a plate (25) which has slots cut in it fitting the pins (22), and so allowing for advance and retard.

This magneto gives two sparks per revolution of the armature, so for a four-cylinder four-stroke engine which requires two sparks per revolution (or four sparks in two revolutions) the magneto must be run at engine speed.

We now come to the high-tension distributor shown above the low-tension make-and-break. The high-tension terminal of the armature secondary is connected by a rubbing contact or "slip ring" to the insulated spindle (3), on which is mounted the distributor arm which supplies current to metal segments embedded in the insulating block (2). Inside this block are wires connecting these segments with the terminals (5), which are connected to the engine sparking plugs.

It is clear that this distributor must only make one turn for every two revolutions of the engine, since in making a turn it distributes current to each of the four terminals. It must therefore run at half engine speed, and so is geared down two to one off the armature shaft. Fig. 4 shows the toothed wheel (8) that drives the distributor, also the spindle (9) on which the distributor is mounted.

One other point. A "condenser" is always used with magnetos; it acts in the same way as with induction coils, but there is no need to pay any attention to it.

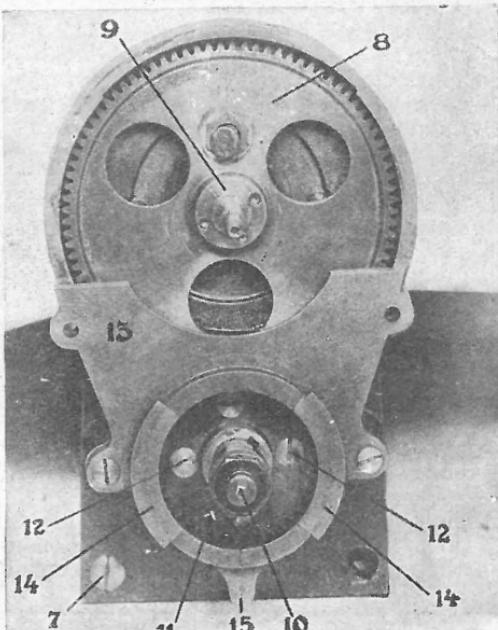
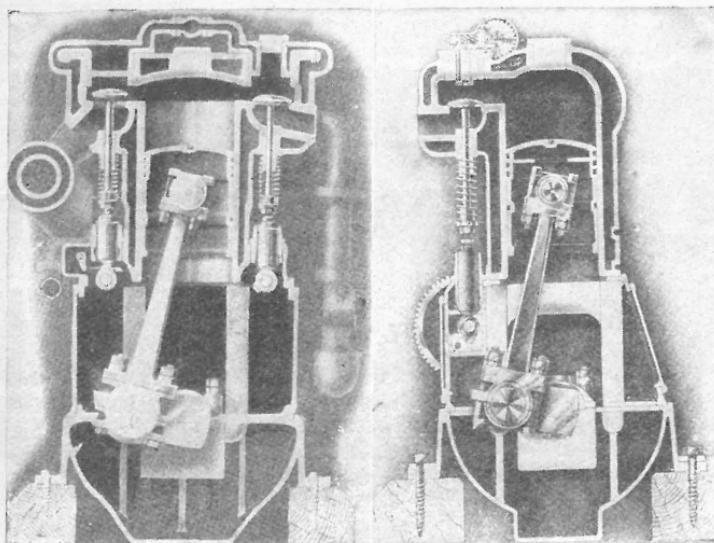


Fig. 4.—End view of the magneto, distributor and contact maker removed.



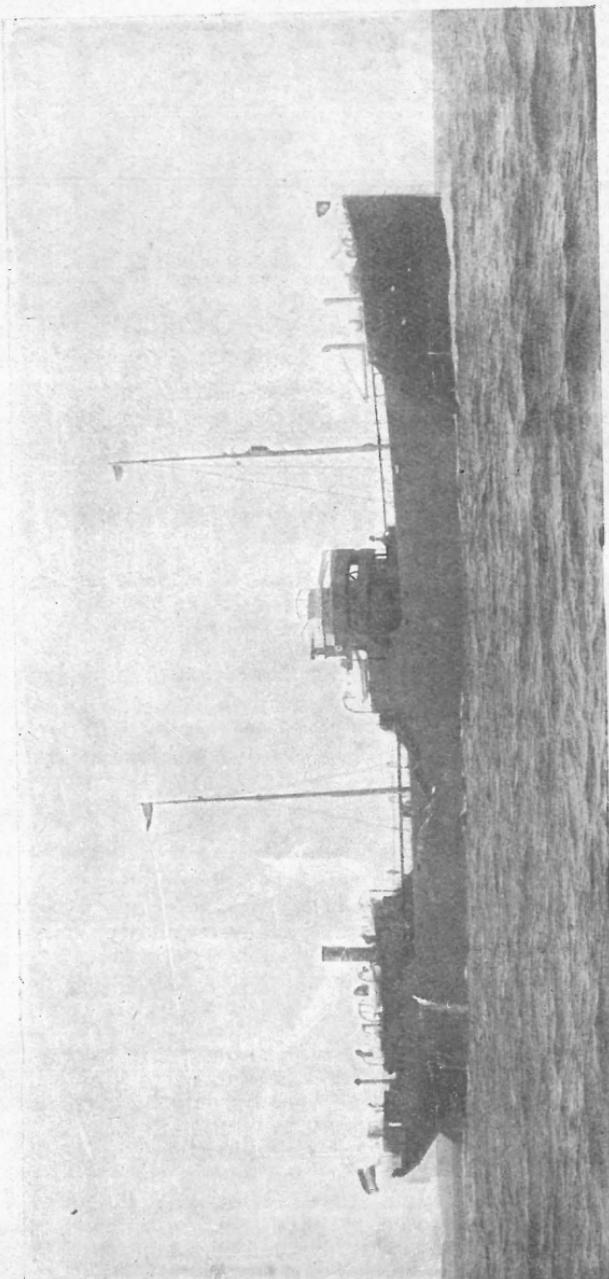
*Section of an engine with valves on opposite sides and section of an engine with valves arranged side by side.
This is discussed in the first chapter.*

Magneto Adjustments.—Practically the only thing that the average man should ever do to a magneto is to adjust the low-tension contact points. To do this he will have to remove the contact screw and clean it up just as if it were the trembler of an induction coil. Even this should never be done more often than is absolutely necessary, and on the whole a magneto is best *let alone*.

Starting a Magneto—Half-compression

It will have been understood that a magneto only generates electricity when it is turning. Consequently, if we are starting up an engine fitted with magneto only it is often necessary to get the engine swinging fairly fast before a spark is produced. To assist in this what is known as "half-compression" is sometimes fitted, a device for making the engine easier to turn, and about which we shall have more to say later. Sometimes, again, battery as well as a magneto is fitted, so that the battery can be used for starting, the magneto only coming into use afterwards.

There is a very simple way of switching off a magneto when it is not wanted. The insulated end of the primary is connected to one terminal of a switch and the other switch terminal is connected to earth. If this switch is switched "on" the primary is earthed independently of the contact breaker. The current, therefore always flows, even though the contact breaker continues to work.



"Hagen," the first large motor ship built by the famous Krupp firm - a notable tank vessel of 1913. She is 400 ft. long, by 49 $\frac{1}{2}$ ft. beam, and 32 ft. depth, with a carrying capacity of 8350 tons. Her engines are two Diesels of 1250 b.h.p. at 135 r.p.m., giving the boat a speed of 11 knots. Each motor has six cylinders 480 mm. dia. by 800 mm. stroke, and is of the two-stroke reversible type.

CHAPTER V

Cooling the Cylinders

WITH explosions taking place in the cylinders, it is clear that an oil engine must get very hot, and to prevent the heat becoming too great it is necessary to water-jacket the cylinders. Fig. 1 shows a section of a cylinder with its jacket. It should be noticed that the water-jacket is carried round the valves, it being very important to cool the valve seatings. The spaces marked A are full of water, B being the cylinder itself, and C the jacket. The letter D marks the "valve caps," that is, gunmetal plugs screwed or otherwise fastened to the cylinder over the valves, the object being to allow the valves to be taken in and out when necessary.

It is not enough simply to fill the jacket space with water, the supply would soon boil away, so an inlet and an outlet pipe are provided and sea water is pumped through the jacket as shown in Fig. 2. Here we have a section of a boat with an engine fitted. On the crankshaft (A) is a small eccentric (B) driving an ordinary plunger pump (C). This takes in water through a pipe (D) led through the bottom of the boat, and delivers it to the cylinder jacket through the pipe (E). The water circulates through the jacket and leaves through the pipe (F) as shown, being taken overboard either above or below the water-line. It will be found that the water as it leaves the cylinders is hot; usually the pipe is quite as hot as is comfortable to hold in the hand.

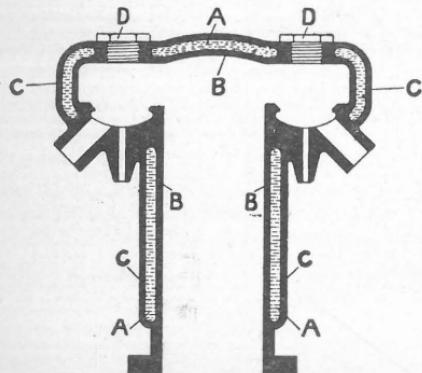


Fig. 1.—Section of cylinder showing water jacket.

Water Pumps : The Gearwheel Pump

The plunger pump, such as we have shown, is very often used, especially on slow-speed engines, but there are many other kinds, the ones most likely to be met with being the gearwheel pump, drum pump, and centrifugal pump. All of these are "rotary" pumps, and are driven off the engine either

by gearing or coupled direct on the end of a camshaft, while occasionally they are chain driven.

Fig. 3 shows a gearwheel pump with one side removed. It will be seen that it consists of two ordinary toothed gearwheels. If the bottom wheel be driven off the engine in the same direction as the hands of a clock, it will, of course, drive the upper wheel in the opposite

direction. Water will be taken in at the right-hand or *suction* pipe, and will be carried to the top and bottom of the pump and delivered through the left-hand pipe. These pumps, when new, will draw water several feet, but when old, like most other pumps, they have to be primed, and so it is always best to fit a pump below the water-line.

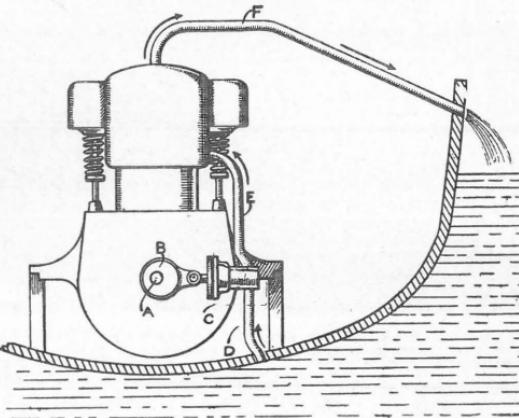


Fig. 2.—Arrangement of pump and water piping in a boat.

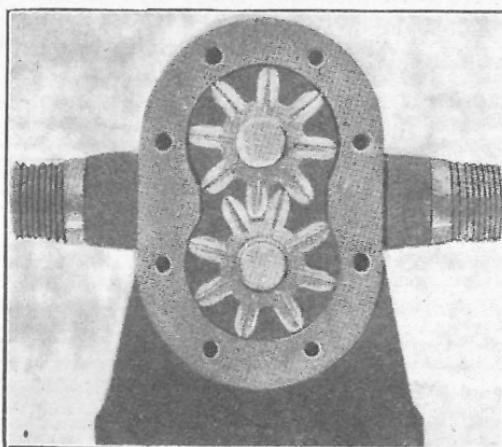


Fig. 3.—The gearwheel pump. If the bottom wheel be driven in the same direction as the hands of a clock, water will be taken in at the right-hand pipe and delivered round the top and bottom of the outer case to the left-hand pipe.

The Drum Pump

Another pump often used with oil engines, especially high-speed engines, is the "drum pump" (Fig. 4). The left-hand view shows the side of the pump in section, the driving shaft being on the left. The right-hand view shows a cross-section. The shaft, it will be seen, is set eccentrically in the pump barrel; there is a slot through it

COOLING THE CYLINDERS

in which two metal wings slide. They are pressed apart by a spring, and so are held against the pump barrel. If the pump be driven the opposite way to the hands of a clock, water will be sucked in at the lower opening and delivered through the other.

The Centrifugal Pump

Most pumps are liable to break or jamb if any dirt should get into them, but the centrifugal pump (Fig. 5) is less affected in this way than any other. It is therefore very useful for use in dirty water, but as it must always be

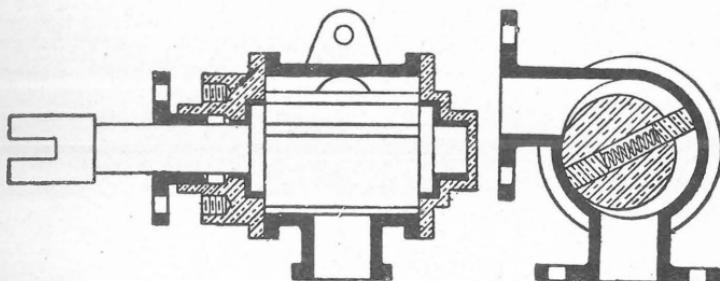


Fig. 4.—An eccentric drum pump. On the extreme left is the shaft coupling by which it is driven.

“drowned,” it is only suitable when installed below the water-line. Water enters at the centre of the pump, which is rotating rapidly, it is caught by the vanes and whirled

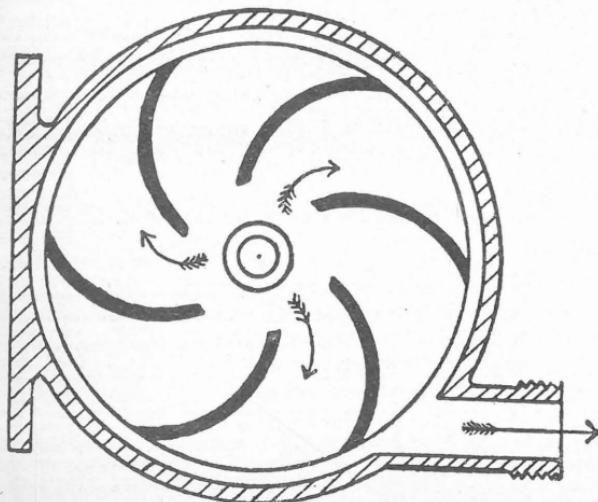


Fig. 5.—A centrifugal pump. The arrows show water is taken in at the centre and delivered to the side of the case.

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round, and is thrown outwards just as a stone flies out when swung round at the end of a string. Water, therefore, is delivered at the outlet in the pump body, as shown by the arrows.

Circulating Water Inlet

We have seen that there is a risk of pumps being choked by dirt or seaweed, and it is therefore best to have some sort of strainer fitted to the intake pipe, which can be got at and cleared without difficulty. The point is not of so much importance in sea-going vessels as in boats used in shallow water or on rivers and canals. Fig. 6 shows a very good arrangement. There is a tube or case (A) with a lid at the top covering the inlet hole (B) in the bottom of the boat. The top of A is carried well above water level, and over B is fitted a wire gauze strainer (C). The suction pipe to the

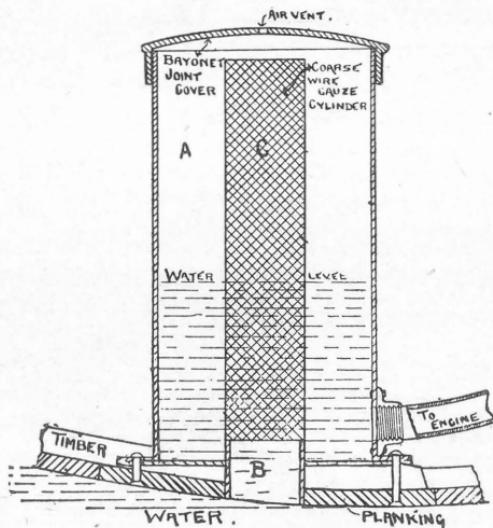


Fig. 6.—A circulating water inlet and filter.

engine is connected as shown. It will be seen that all water going to the pump has to pass through the strainer, and any weed or dirt is held inside the gauze. Should this become completely choked, the lid can be taken off the case (A) and a stick pushed down to clear the weed out of the strainer.

CHAPTER VI

Lubricating an Engine

MANY people who have little to do with machinery are inclined to think that lubrication is not a very important matter. Their idea is that a little oil must be poured into a tank at any time that may be convenient; for the rest the end of an oilcan is now and then put into whatever oil-holes are the easiest to reach. Now, the first thing for everyone to realize who has to do with an engine or machinery of any sort is that *lubrication is the most important thing of all*. Inattention in other ways may cause an engine to run badly, or cause trouble in one way or another, but nothing is so certainly fatal, and nothing so expensive to repair, as damage due to faulty lubrication. So long as an engine is properly oiled, nothing very serious is likely to happen to it, and so, whenever the reader has to take charge of a new motor, he should thoroughly master every detail of the oiling system before he attempts to run it. There are several different ways in which lubrication may be carried out; in fact, nearly every oil-engine builder has a method of his own, but all can be divided under three principal systems: (1) splash and drip lubrication; (2) forced feed, in which oil is pumped under pressure to the bearings; (3) a combination of the first two systems, in which a pump is used to maintain the splash and drip feeds.

Splash Lubrication

Splash lubrication is very easily explained. Fig. 1 shows a four-cylinder engine, with a side of the crankcase removed.

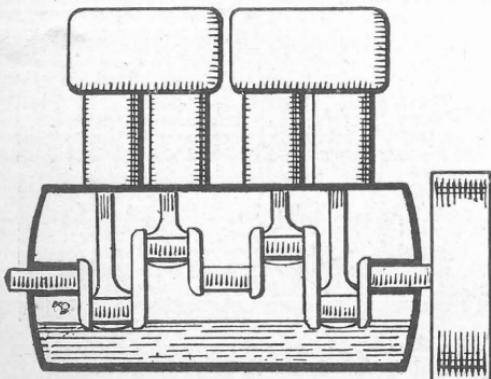


Fig. 1.—Diagram of splash lubrication on four-cylinder engine.

There is a pool of oil in the bottom of the case, and the connecting rod big-ends just dip into it at the bottom of their stroke. They are fitted with small scoops, which carry oil to the big-end bearings, and also throw it up in a stream, some of which falls into oil-holes over the main bearings, the rest being scattered over the camshaft, the gear wheels (if enclosed in the crankcase), and also thrown up inside the cylinder walls and the small-end or gudgeon pin bearings are lubricated. The supply of oil can be kept up by pouring it into the crankcase from time to time, but a better arrangement is shown in Fig. 2. Here we have a drip lubricator, which is filled from time to time, and supplies oil to the crankcase through a pipe, as shown. The engine shown is a small two-stroke, two-cylinder model, in a larger engine the single lubricator would be replaced by a different pattern, consisting of a small oil tank mounted on the engine, with a row of, perhaps, half-a-dozen drip feeds in glass tubes, from which the oil is led to various bearings, probably to each main bearing, and through a hole in the bottom of the cylinder to the cylinder walls. Fig. 3 shows the arrangement of a row of sight drip feeds, with small copper pipes to the bearings. Strictly speaking, the lubrication of this engine comes under Class 3, because these drip feeds are supplied by a pump, but the same sight-feed arrangement is employed when an oil tank is used. Splash and drip lubrication is undoubtedly the simplest, and answers very well indeed on moderate speed engines. There is, however, one objection that has to be guarded against.

Fig. 4 shows what happens when the engine is installed at an angle. The oil all runs to the after end, so that the forward cylinders get no oil, and the after ones get too much.

However, most modern engines with splash lubrication have a web across the middle of the crankcase (see Fig. 5), so that the change of level of the oil does not matter so much.

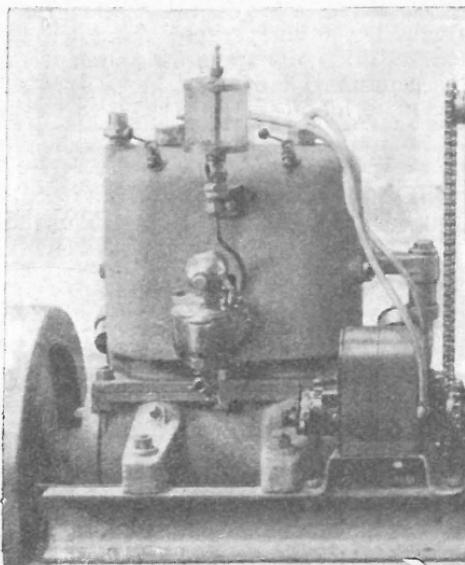


Fig. 2.—An engine with splash lubrication, with drip lubricator to keep up the supply.

LUBRICATING AN ENGINE

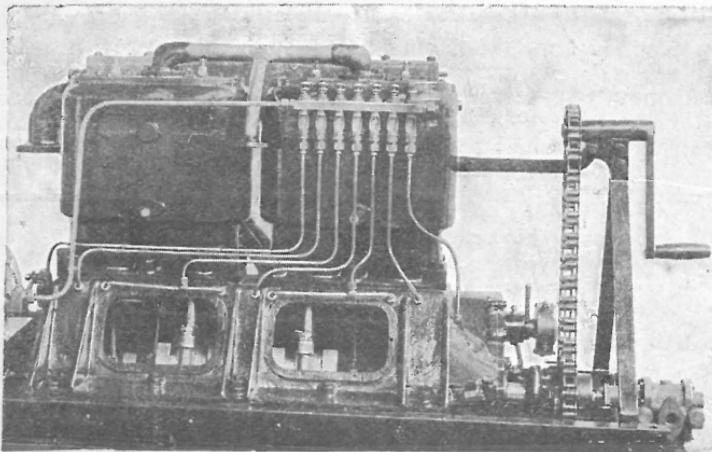


Fig. 3.—A four-cylinder motor with a row of pressure-fed sight feeds.

Forced Lubrication

Forced lubrication was not used on oil engines until long after the splash and drip system, but it is now very popular, and is being more used every day. In Fig. 6 the bottom

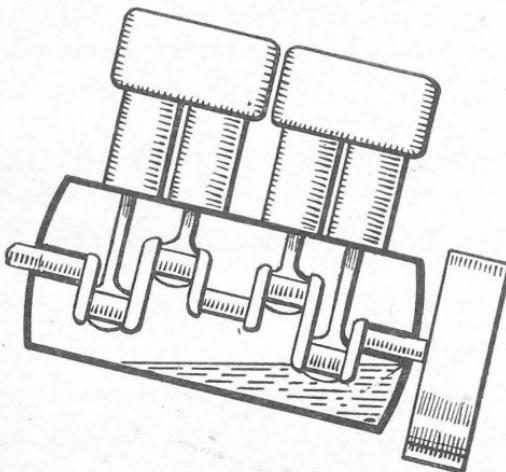


Fig. 4.—The effect (exaggerated) of installing an engine at an angle. Oil runs to the after end and the forward cylinders are left dry.

part of an engine crankcase is shown in diagram form, as also are the pistons, connecting rods and crankshaft, the cylinders being removed.

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Underneath the crankcase is a well, or " sump " (A), which is kept just full of oil, but not enough to overflow into the crankcase itself, so that the big-ends do not dip in oil at all. A pump (B), driven by an eccentric (C) off the crankshaft takes oil from the sump, and delivers it through a filter or strainer (D) to a two-way cock (E). Here there is an adjustable by-pass (F), which returns all excess of oil to the crankcase, the " tell-tale " or gauge (G) showing if the pump is

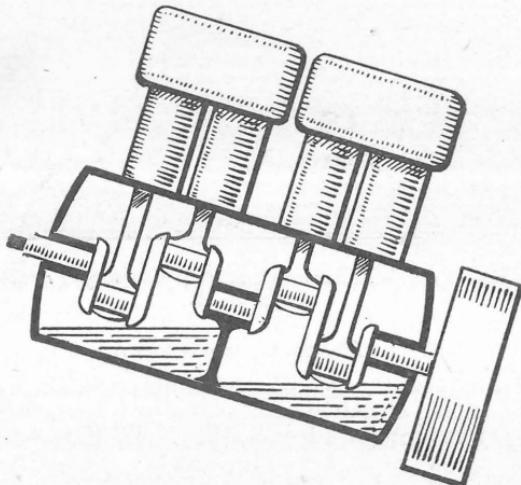


Fig. 5.—Splash lubrication with central web to prevent supply of oil being affected by angle of engine.

working. The rest of the oil is delivered through pipes to the three main bearings, the pressure being set by means of the by-pass to whatever suits the engine; from 1 lb. to 15 lb. to the square inch are the usual limits. From the main bearings the oil passes through holes bored in the crankshaft web to the big-end bearings. In some cases it is led from these through pipes up the connecting rods to the gudgeon pins. These pins are hollow, so that the oil flows through them to the cylinder walls, and from there drains back to the sump, to be used over again. This arrangement



Fig. 6.—Sight-feed lubricating system supplied under pressure from a pump, as frequently adopted with British marine motors.

LUBRICATING AN ENGINE

is shown on the left-hand cylinder only. Often the oil is allowed to escape at the sides of the big-end bearings, whence it is splashed to the cylinder walls and gudgeon pins. So long as the pressure gauge or tell-tale is working, the engineer in charge knows that all is well with the lubrication; if the by-pass shows that no oil is passing, it is a sign that more must be poured into the crankcase. So long as it is working properly, forced lubrication is undoubtedly the best. The only danger lies in one of the pipes leading to the main bearings getting choked, for if this happens, a bearing may seize up without any warning. But forced lubrication is now so well arranged that there is very little danger of this happening, and all the user of the engine has to remember is to keep the filter clean and never to allow dirt to get into the crankcase.

Pump-fed Splash Lubrication

There is little to explain in this system. The drip feeds may be supplied under small pressure by a pump, as shown in Fig. 3, the pump being visible at the left-hand end of the engine, or there may be a sump under the crankcase, from which oil is delivered to a small trough under each big-end, whence it is splashed everywhere. The advantage of these troughs is that they are always kept filled to overflowing, and so keep a constant level of oil, which, moreover, is practically unaffected by the angle at which the engine is installed.

Multiple Pump Lubricator

An excellent method of forced lubrication now being largely adopted is a system of a number of small plunger pumps operated by a series of cams, or eccentrics, on a small ratchet-driven layshaft. Each pump is adjustable, and thus the exact amount of oil to each working part can be regulated. The pump container also forms the oil supply tank, and it can be mounted in any convenient position where it is "get-at-able," so that adjustment becomes easy. This arrangement is to be seen on Continental and American motors rather than on British engines, so, perhaps, is not familiar to many in this country. Generally, this practice is to be found on slow-speed engines, and not on those of the faster type.

Cooling the Oil

In some very large engines it has been found desirable to cool the lubricating oil by passing it through a coil of pipe in a water trough, or by water-jacketing the bottom of the crankcase. Another way is to take the cylinder cooling water through a coil of pipe in the crankcase sump.

CHAPTER VII

Silencing the Exhaust Gases

WE have seen that the exhaust of an oil engine escapes through a valve or port from the cylinder. When the valve first opens there is still some pressure behind it—10 lb. to the square inch or so—and if this exhaust gas is allowed to escape straight into the air a sharp report is produced on each exhaust stroke, so that an engine, running with

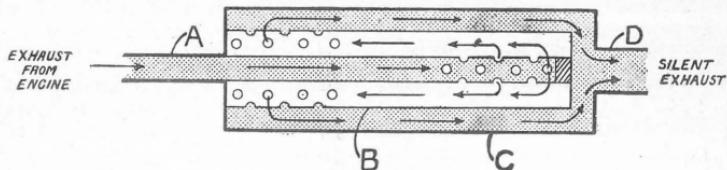


Fig. 1.—A simple type of silencer.

an open exhaust, makes a noise like a quick-firing gun. To get over the trouble a "silencer" is used, the object being to break up the gas and allow it to escape gradually.

There are a great many different patterns of silencer, but in all the principle is very much the same, and may be easily understood from Fig. 1. A is a pipe connected to the exhaust port of the motor, closed at its right-hand end and perforated with holes as shown. Outside this pipe is another pipe or tube (B) with holes at its left-hand end, and outside this again is a third tube (C) with a single outlet (D) at its right-hand end. The exhaust gas from the engine passes along the tube (A), escaping through the small holes into the tube (B). It then travels back through B and through the holes at the end of it into the outer case (C), and finally escapes through the outlet (D). The gas is thus slowly allowed to expand and cool as it passes through the silencer, and, being well broken up by the time it reaches the outlet, produces little noise. Any number of tubes (in reason) may be used; the more there are of them the more quiet will be the exhaust; the only limit is the amount of the resistance to the passage of the exhaust that

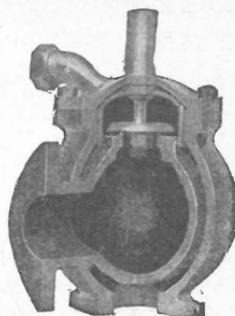


Fig. 2.—The Langdon Silencer.

SILENCING THE EXHAUST GASES

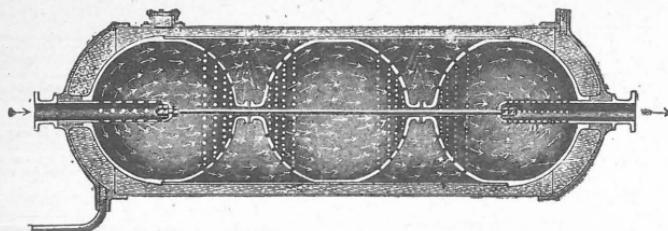


Fig. 3.—A water-cooled silencer.

the silencer offers. If this be too great it sets up a back pressure on the engine and causes loss of power, just as the condenser of a steam engine may do if it is not working properly.

How a Silencer is fitted

A silencer may be fitted close to the engine or it may be some distance away, with a long pipe between the two, so that it can be put in whatever position happens to be convenient. Sometimes it is fitted on deck like the funnel of a steamer, sometimes it is in the engine-room, and sometimes under a thwart or in the stern locker. The outlet (D), again, may be quite short or it may be a long pipe leading outboard wherever most suitable. Usually it is found best to keep the exhaust above the water-line, but occasionally one finds it below. Sometimes one way is best, sometimes another.

Heat of the Exhaust—Water Cooling

The exhaust, when it leaves the engine, is very hot, not so hot as when the explosion first takes place, but still hot enough to make a cabin very unpleasant and even to char woodwork that is too near it. For this reason exhaust pipes are often lagged with asbestos, but a much better way is to water-jacket them just as cylinders are water-jacketed. The same water that cools the cylinders can be passed through the pipe jacket without the use of an extra pump, and the jacket should also be continued round the silencer. Fig. 3 shows one type of water-jacketed silencer and also gives an arrangement for breaking up the exhaust that takes the place of the tubes shown in Fig. 1.

Fig. 4 shows a patent silencer largely in use, and in which the water is admitted in the form of a jet. This mixes with the exhaust gases and cools them, and the two pass out together. To prevent back pressure there is an automatic valve.

In Fig. 4 we show how a funnel exhaust may be arranged.

Squirting Water into the Exhaust Pipe

There is another way of quieting the exhaust and at the same time cooling it that is cheaper and nearly as satisfactory as the use of silencers and water jackets, at least,

with multi-cylinder engines. Part of the cylinder cooling water is sprayed directly into the exhaust pipe. Meeting the hot gases, the water at once cools them, while a little steam is formed, and if the pipe be 10 ft. or so long it will be found that the exhaust is as silent as need be. With this arrangement it is important

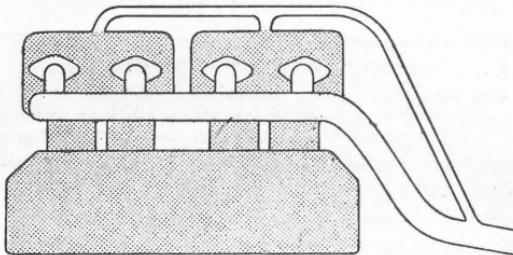
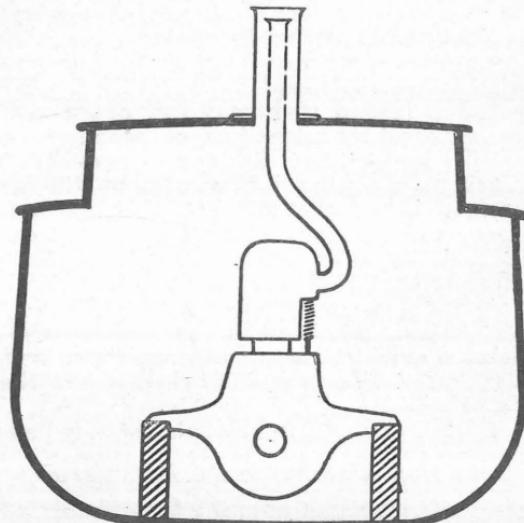


Fig. 4.—Silencing by water injection.

that there should be a good drop in the pipe between the valves and the point where water enters, otherwise there is danger of water getting back into the engine. Also, the exhaust should be above water, and the pipe should have as straight a run as possible, with a steady fall all the way to the outlet. To avoid back pressure, an automatic relief valve must be fitted to the exhaust pipe.

Occasionally one finds a combination of the silencer and water-injection systems.



*Fig. 5.—How a funnel exhaust may be arranged.
The silencer is usually fitted in the funnel.*

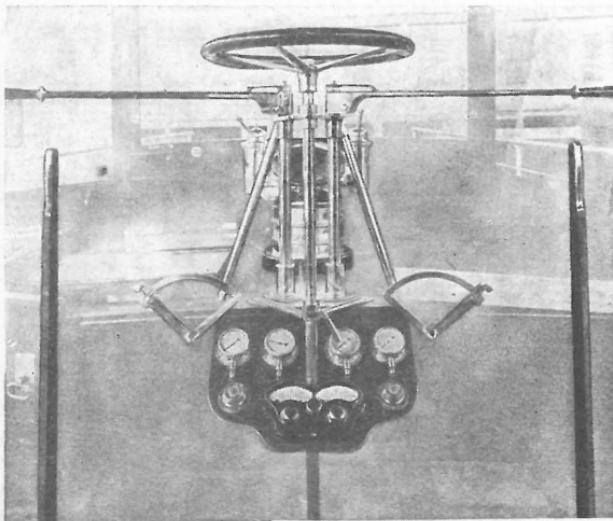
CHAPTER VIII

Starting and Control Arrangements

IT is in starting up that one of the great differences between oil engines and steam engines lies. With the steam engine we simply open a valve to admit steam from the boiler and the engine starts. That cannot be done with an oil engine. We have to have the engine turning to produce the suction required to draw a charge into the cylinders and then to compress it, etc. Therefore, outside means have to be employed to get the engine turning before it will commence running on its own power. When we come to describe some actual engines, we shall see that many makes have special means of starting of their own. For the present, therefore, we will only give a general idea of how starting may be accomplished.

Starting by Hand—Half Compression

There is little difficulty about starting up small engines. There is a handle provided, usually with a chain connection



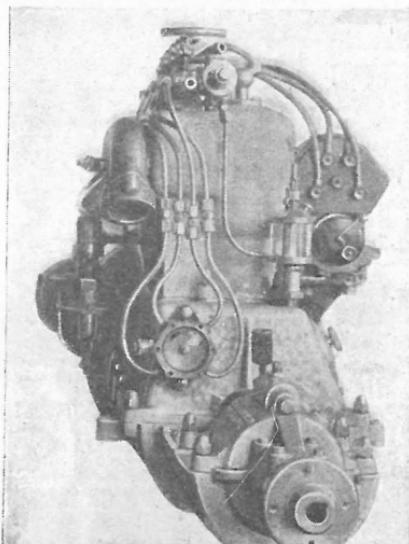
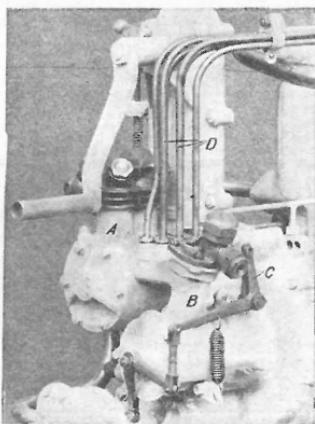
Neat deck control of a 66-ft. motor vessel that enables her to be run single-handed.

to the crankshaft, and the engine is simply turned by hand or pulled over the compression until it commences firing. On engines of any size the compression makes it difficult to turn an engine by hand, so *half-compression* gear is sometimes fitted. This consists of extra cams on the cam-shaft, arranged to open the exhaust valves slightly during the compression stroke, allowing part of the charge to escape. In this way quite a large engine can be turned at a good speed by hand, as soon as it starts firing full compression is put in, and it continues to run in the ordinary way.

Starting by Compressed Air

Very often compressed-air starting gear is used, especially on big engines. There is a reservoir of air compressed usually by means of a pump driven by the engine, or possibly filled with exhaust gas. By means of special valves air is admitted to each cylinder at the beginning of each explosion stroke.

An air compressor fitted to a marine motor. (A) The compressor; (B) the distributor, (C) controls; (D) air pipe from distributor to cylinders.



End view of a motor, showing the air distributor (cover off).

So soon as the engine picks up the air supply is cut off and the tank or reservoir again pumped up to full pressure. Some engines, however, utilize the explosion in one or more of the working cylinders to charge the storage air tanks, thereby saving the cost of a compressor. But with this system it is necessary to charge the storage tanks by hand pump should the pressure give out before the engine is set going. Sometimes, however, small auxiliary compressor sets are fitted as a standby.

STARTING AND CONTROL ARRANGEMENTS

Pumping a Charge into the Cylinder

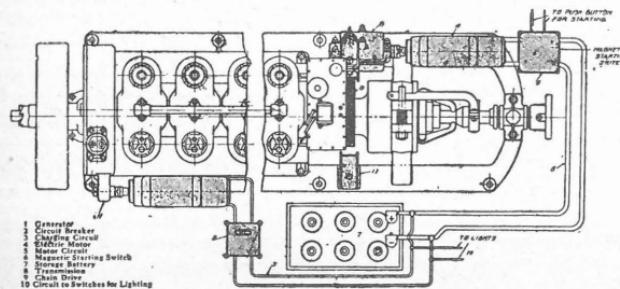
There also is a variation of the compressed air method of starting. The engine may be set to a firing position and a charge of petrol and air pumped into the cylinder by hand. So soon as the pressure is as great as can conveniently be managed, the charge is exploded and the engine starts away.

Electrical Self-starters

Electricity is now being largely adapted for self-starters in marine work, particularly in cases where electric light is also required. The year 1913 saw many such devices placed upon the market, and we give a typical example of a combined electric lighting and starting set. Many models however, have not the lighting equipment combined, such as the Hartford, which we also give.

The Loew starter is generally installed in conjunction with the Loew-Victor marine engines. This system is not so compact as some sets, in which the dynamo and motor are one, as in this case the set consists of a 24-volt dynamo, a motor, and a 24-volt battery of 50 ampere hours capacity, but there are good reasons for separate units. The motor is mounted on the engine base, with its armature shaft in a vertical position, and is connected to the crankshaft through a worm gear and silent chain drive. When the engine is running the clutch is thrown out of engagement and the motor remains stationary. Between the dynamo and battery is arranged an automatic cut-out, with an illuminated signal bearing the words "off" or "charging," as the case may be. A magnetic control switch is fitted, and this can be arranged in any convenient position. Apart from the current required for starting the engine, the lighting capacity is about 100 candle-power, which is ample for a small yacht. The system is illustrated below.

With the Hartford electric system (next page), the motor used for starting is very small and light, and rotates at about 7000 r.p.m. So it is necessary to drive the forward extension of the engine crankshaft through a double reduction

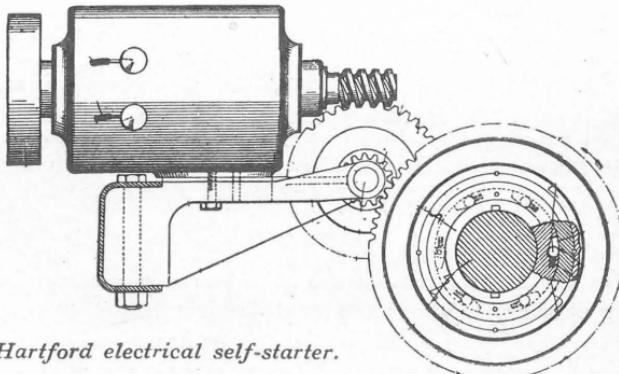


Loew electrical starting and lighting equipment.

gear, in which the first step is obtained through worm gearing and the second through ordinary spur gearing. To increase the efficiency of the motor and permit it to maintain its high rotative speed at the moments when the pistons of the engine are passing compression dead centres, it is fitted with a small flywheel weighing approximately 4½ lb. Between the motor and the gearing there is a roller clutch mechanism, which permits the main engine to overrun the electric motor.

Control of Engine Speed

The speed and power of a steam engine can be controlled by means of a throttle valve, admitting more, or less, steam to the cylinders as may be required, and in exactly the same way a throttle can be fitted to the vaporizer or carburetter of a motor. Throttles take various forms. There is what is called a "butterfly" throttle, fitted in the inlet pipe, as shown in the sketch (Fig. 1). A is the pipe in section, the bottom end being supposed to be connected to the carburetter. B is the "butterfly," and in the position



Hartford electrical self-starter.

shown the valve is closed. Outside the pipe is a lever (C), connected by a rod (D) to the hand control lever (E), pivoted at F and moving over notches in a quadrant (G). If the lever be pulled back to the position of the dotted line the throttle will be fully open, and various degrees of opening can be obtained between these two positions.

Piston throttle.—There is another much-used type of throttle called the piston throttle, which is very useful for setting the air ports of a carburetter to suit the needs of the engine. We have already mentioned that carburetters usually have extra air valves or ports, admitting more air as the engine speed increases. Fig. 2 shows how this extra air may be provided by means of the piston throttle, so that one hand lever adjusts both air supply and quantity of gas at the same time. The carburetter shown is not a copy of any particular make, it must only be considered

STARTING AND CONTROL ARRANGEMENTS

as a diagram. The jet (A) is shown inside a horizontal pipe (B), from the right-hand end of which air enters, and passing over the jet takes a rich mixture into the mixing chamber (D). The jet is supposed to be supplied from an ordinary float chamber (C), shown behind the rest of the carburettor. In the top of the mixing chamber is a hole (E) for extra air to enter, and there is another outlet (F) by which the mixture passes to the cylinders. Inside the chamber (D) is a tube or piston (G), which forms the

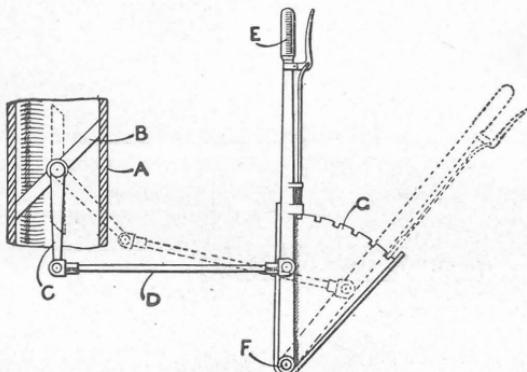


Fig. 1.—The "butterfly" throttle.

throttle. It is attached to a control rod, which can be moved backwards and forwards, as shown in Fig. 1, by means of a hand lever. There is a port (K) cut in this sliding piston which, as the piston is moved over to the left, communicates with the outlet (F), and so allows gas to pass to the cylinders. In Fig. 2 this port, and also the extra air port, is shown closed, but in Fig. 3 the throttle is partly open. The extra air port is only just beginning to open, this being due to the end of the piston throttle overlapping it when closed. This is done purposely, because extra air is not required at low speeds. In Fig. 4, however, the throttle is fully open, and so is the extra air port, and air is shown rushing in to mix with the mixture coming from the jet.

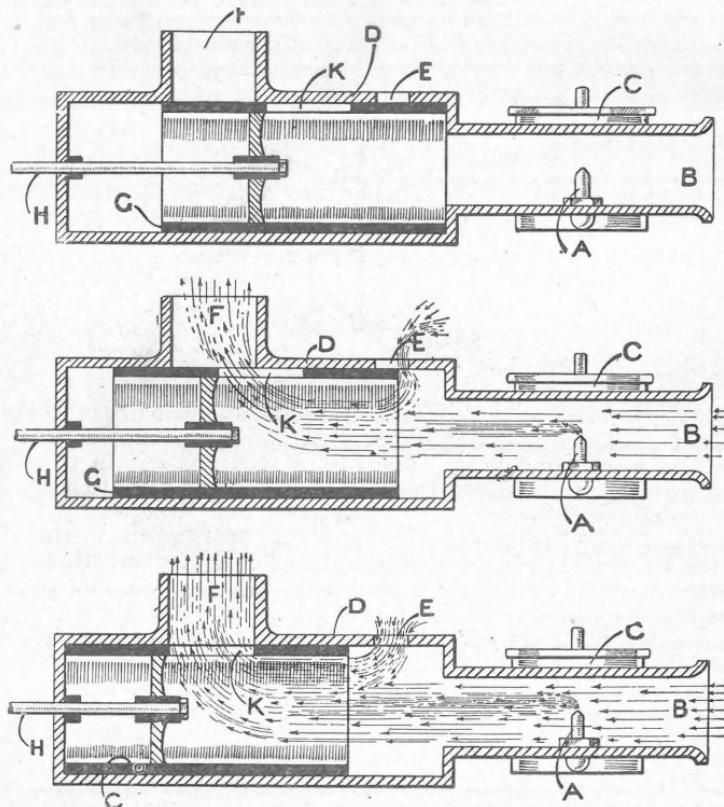
Ignition Timing

It has already been explained that when high-tension electric ignition is used the spark is advanced and retarded to suit the speed of the engine. It is usually necessary to work the ignition lever quite independently of the throttle. Sometimes, however, the two are connected together by the engine builders, so that one lever opens the throttle and advances the ignition at the same time. The same arrangement can be used with magneto ignition, unless, as is sometimes the case with commercial paraffin-petrol engines, the ignition point is fixed.

Separate Air Adjustment

A good many carburetters have a hand air adjustment separate from the throttle. When this is the case there is an extra lever to look after, but experience will very soon show how it must be used. If the engine is receiving too rich a mixture, firing back into the carburetter will often occur, and this is a sign that extra air is required.

What has been said applies principally to control of engines with float feed, spray carburetters or vaporizers. When a drip feed to a hot vaporizing chamber, or oil injec-



Figs. 2, 3 and 4.—Combined throttle and air control for a carburetter.

tion direct to the cylinders is used, adjustments are made in various ways which will be described when engines of these classes are dealt with. The stroke of the fuel pump may be varied, or there may be governing on the hit-and-miss principle. Sometimes there is a pump to each cylinder, and occasionally a single pump with a distributor.

STARTING AND CONTROL ARRANGEMENTS

Stopping an Engine

With hot-bulb ignition an engine must be stopped either by shutting off the fuel supply, allowing air only to be taken in, or by completely closing the throttle if the motor is of the drip-feed type. When electric or magneto ignition is used, the simplest way of stopping is simply to switch off the current in one case or short circuit the magneto in the other.



Brailing for salmon on the Pacific coast of North America. Motor craft are very largely in use in connection with this industry. Sometimes as many as 30,000 fish are caught at one setting of the traps.

CHAPTER IX

Transmission and Reversing Systems

THE CLUTCH.—Though air starting gear makes it possible to start a motor as quickly as a steam engine, large tanks would be required to enable an engine to be started and stopped as often as is sometimes necessary when going in or out of a harbour, and so a small oil engine is seldom coupled rigidly to its propeller unless a reversible propeller (which will be explained later) is used with an engine of only 5 h.p. or 6 h.p. Even then, in our opinion, it is much better to go to the slight extra expense of a clutch, for it is extremely difficult, and in some cases impossible, to set the blades of a propeller in an exactly neutral position. The result is that the boat is always trying to go either ahead or astern, so that

she cannot be left unattended even for a couple of seconds with the engine running; it is much better, therefore, always to have a clutch. There is only one oil engine with which a clutch is never used, the reversible Diesel: in this case very high pressure pumps are required for the engine

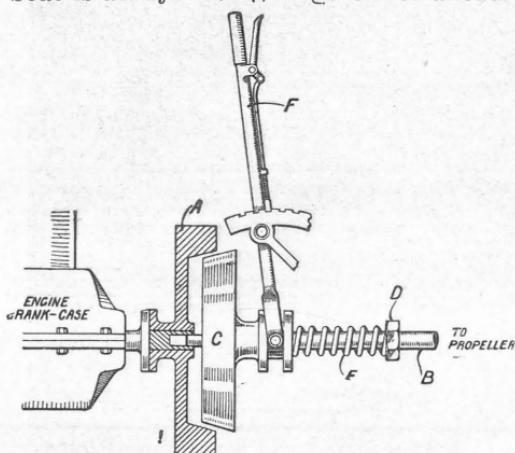


Fig. 1.—Diagram of cone clutch.

itself, so that there is no difficulty at all about providing enough compressed air.

By far the commonest form of clutch is the cone variety shown in Fig. 1. The flywheel (A) coupled direct to the engine crankshaft is turned inside to a cone or taper form, as shown. The propeller shaft (B), instead of being coupled direct to the engine as in a steam boat, has a clutch

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member (C) on its forward end corresponding to the clutch member (A). There is a fixed collar (D) on the propeller shaft; the cone (C) is on a sliding key or "feather" on B. Bearing against the collar (D) is a very strong spring (E), which forces C forward so that it engages with A and transmits the drive to the propeller. It will be noticed that there is a groove in the right-hand end of the boss of the clutch member (C), in which the forked end of a hand lever fits. If this lever be pushed forward it will draw back the clutch member (C) against the pressure of the spring, disengaging the clutch and leaving the propeller free. The sketch, of course, is only diagrammatic. In practice the cone (C) has usually a leather face, which is kept dressed with oil, or sometimes a metal-to-metal clutch is used instead of leather to metal.

Reversing

A great many users of oil engines, having been used to sailing boats, do not feel the need of reversing or going astern at all; indeed, in motor auxiliary vessels of any sort reversing mechanism is not really necessary. Still, it is always a convenience to be able to go astern. Very few oil engines are reversible like a steam engine, and fewer still are reversible without the use of compressed air for restarting in the opposite direction. There are two ways of obtaining an astern drive with the engine always turning one way, the reversing gear and the reversing propeller.

Reversing Gears

There are a very great number of reversing gears on the market, and to describe all would take up far too much space. We will, however, explain how two of the number work. First we will take the Parsons gear, an illustration of which, with the top of the case removed, is shown in Fig. 2. The gear, it will be seen, is extremely simple. There are two shafts, a pair of gear wheels, and a chain drive. Fig. 3 shows the arrangement in section looked at from above. The action of the gear depends upon the fact that, if one shaft be driven by another by means of a chain, both shafts turn in the same

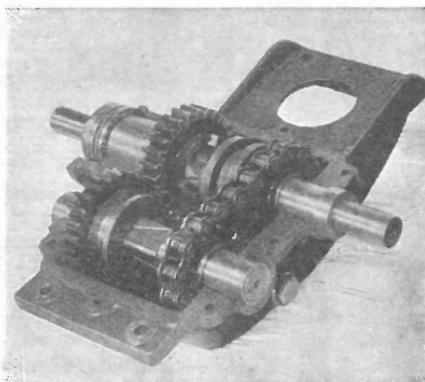


Fig. 2.

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direction; if instead of a chain a single pair of gear wheels be used, the two shafts will turn in opposite directions. In Fig. 3, A is the engine shaft, on which runs a loose chain wheel (B) and a double-faced jaw clutch or sliding coupling (C). This coupling is carried on a squared portion of the shaft so that, though it can be moved sideways, it always rotates with the shaft. On the left is the propeller shaft (D), to which is keyed a gear wheel (E). Both the chain wheel (B) and the gear wheel (E) are provided with jaw couplings corresponding to the sliding coupling (C). If, therefore, C be moved to the left to engage with E a direct ahead drive will be transmitted from the engine to the propeller shaft.

We now come to the reverse drive. There is a counter-shaft (F), to which a chain wheel (G) is keyed, and there is a gear wheel (H) carried on a squared portion of the shaft, so that it rotates with it, but can be moved sideways in the same way as the sliding coupling on the shaft (A). Both H and C are moved sideways by means of a hand lever such as was shown in Fig. 1, and they are so connected that, while C moves to the right, H moves to the left, or if C is moved to the left H moves to the right. In the drawing the gear is in "neutral," that is to say, neither side of the sliding coupling is engaged, and the

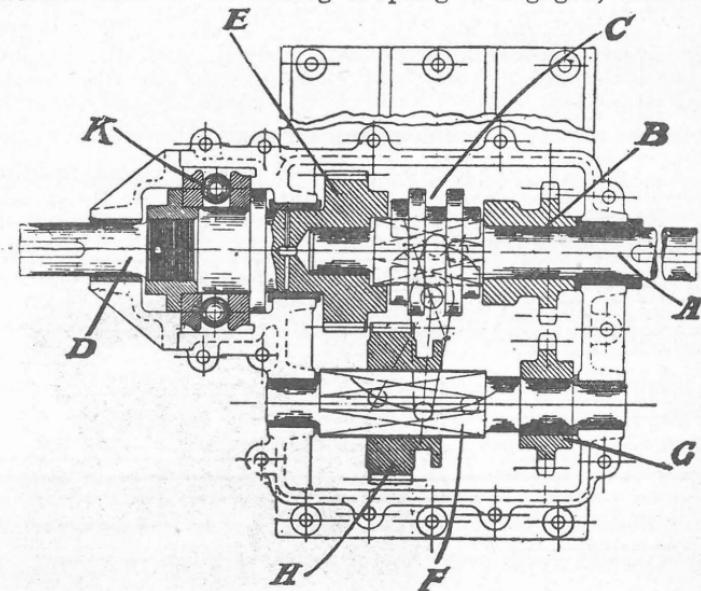


Fig. 3.—Section of Parsons gear.

propeller shaft remains at rest while the engine is running. We have already seen that moving C to the left gives an ahead drive, H being moved still further to the right out of the way. Now, if C be moved to the right

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to engage with the chain wheel (B), H is moved over to the left and slides into mesh with the gear wheel (E), which we have seen is keyed to the propeller shaft. The chain wheel (B), which is, of course, connected by a chain to the wheel (G), drives a shaft (F) in the same direction as the engine shaft. The gear drive from H to E, therefore, drives the propeller shaft in the opposite direction, thus giving an astern drive. With this gear, although there is a "neutral" position, a clutch is required to be fitted between the engine and gearbox, which must be disengaged whenever the gear is operated. Otherwise it would not be possible to make the sliding coupling engage with E and B. It should perhaps be mentioned that the name "dog clutch" is often given to this type of coupling.

Thrust bearing.—It will be noticed that there is a ball-bearing (K) on the propeller shaft behind the gearbox. This is to take the thrust of the propeller, and corresponds exactly to the thrust collars generally used with a steam engine, with which most readers will be familiar.

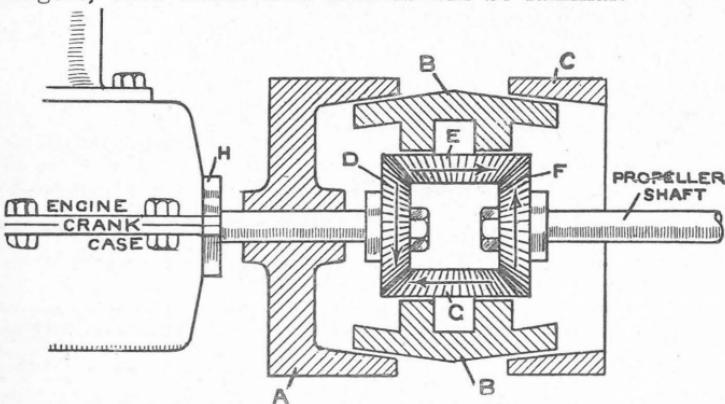


Fig. 4.—Double cone clutch and differential reverse gear.

Clutch and Reverse Gear Combined

We now come to a different kind of gear, in which clutch and reverse gear are combined and worked by a single lever. Fig. 4 shows a diagram of the arrangement. There is the cone clutch shown in Fig. 1, the flywheel (A) being faced internally, and there is the other cone member (B) is tapered each way. If moved to the left it engages with A ; if moved astern, that is to the right, it engages with another cone (C), which, however, is fixed in the boat so that B is held fast when engaged with it. Inside B are four bevel gear wheels (D, E, F, G), all meshing together as shown. D can slide on a squared portion of the engine shaft, E and G are free to revolve, but are carried by the double cone (B) and rotate with it. F is keyed to the propeller shaft.

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The propeller shaft has a slight fore-and-aft movement. Now suppose B, with its bevel gears, to be moved to the right, that is aft, to engage with C, B, as we have seen, will be held fast, and if the engine drives the bevel wheel (D) in the direction shown by the arrow a little thought will show that the bevel (F), and with it the propeller shaft, will be driven in the opposite direction through the bevels E and G. That is, we have an astern drive. Now, if B is moved ahead to engage with A, it and all its bevel wheels will be driven round the same way as the engine, the gears being locked and rotating as a solid mass, so that we have an ahead drive.

Gears of this kind are practically fool-proof, and there is the advantage of having only one lever to look after. It is, however, important when ordering a gear to make sure of getting one amply big enough for the power it has to transmit, otherwise the clutches may slip. A little money might be saved by ordering a small gear, but it is the worst possible practice to risk having too small a gear.

It has been mentioned that with this gear the propeller shaft moves slightly. This enables springs to be done away with altogether in the clutches, the propeller thrust being used to keep the cones in engagement. In this case the thrust bearing is carried on the engine itself, as shown at H.

There are several variations of this type of gear, but there is no need to describe them fully here. Instead of the form of double clutch shown, one clutch is sometimes put inside the other, and instead of the bevel gearing just described what is called an epicyclic gear can be used. But there is little need for the driver to know much about the inside of a reverse gear. The gears are always enclosed, and so long as he has a general idea of how they work and keeps them well filled with oil that is all that need trouble him.

Reversing Propellers

We now come to the second method of driving a boat astern, reversing propellers. Everyone knows what an ordinary propeller looks like. It has two, three or four blades set at an angle to the boss, which drive ahead if run in one direction and astern if run the other. With a reversing propeller the same result is obtained by always running one way and "feathering" or reversing the angle of the blades. There are a number of different patterns of reversing propeller, but it will be enough to show one way in which the principle of shifting the blades may be carried out.

A Practical Example

Fig. 5 shows a well-known make of propeller in section and (on the right) the mechanism by which the blades are moved from inside the boat. The boss (A) is cut across

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and hollowed out. The propeller shaft (B), to which the boss is screwed, is also hollow throughout its length, and carries a central rod (C), which can be moved fore and aft and which serves to feather the blades. At the end of C, inside the boss, there is a block (D) with a pin (E) corresponding to each propeller blade, and set eccentrically to the centre line or axis of the blade. Each blade has a bearing in the boss with a spherical, or dome-shaped, lower end or root, the shape being intended to make the blade perfectly rigid and free from shake. There is a slot in the under face of the root corresponding with the pin on the block (D), so that a fore-and-aft movement of the central rod (C) and its block (D) causes the blade to turn, giving a drive either ahead or astern as may be required.

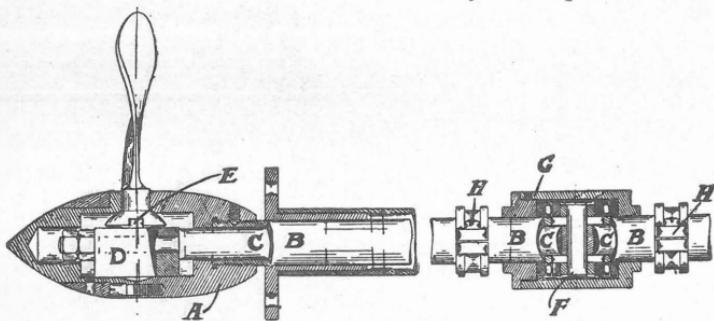


Fig. 5.—Reversing propeller mechanism.

We will now turn to the means by which the block (D) is moved. The rod (C) (see right-hand portion of Fig. 5) is bored through to take a pin (F), and there is a long slot in the propeller shaft (B), through which the pin (F) projects on either side. The pin is carried by an outer sliding sleeve (G), fitted with ball thrust bearings, and the whole sleeve is controlled by a hand lever (not shown), by which it can be moved fore and aft to the limit of the slot in the shaft (B), thus feathering the propeller blades. In practice stop collars (H) are fitted to the propeller shaft, limiting the movement of the sleeve, and set by experiment to give the best speed with the engine of any particular boat.

Another very widely-used reversing propeller differs from the one just described in having a flat instead of a dome-shaped root to the blades; also, to avoid slotting the shaft for the hand-lever gear, a special hollow casting is used.

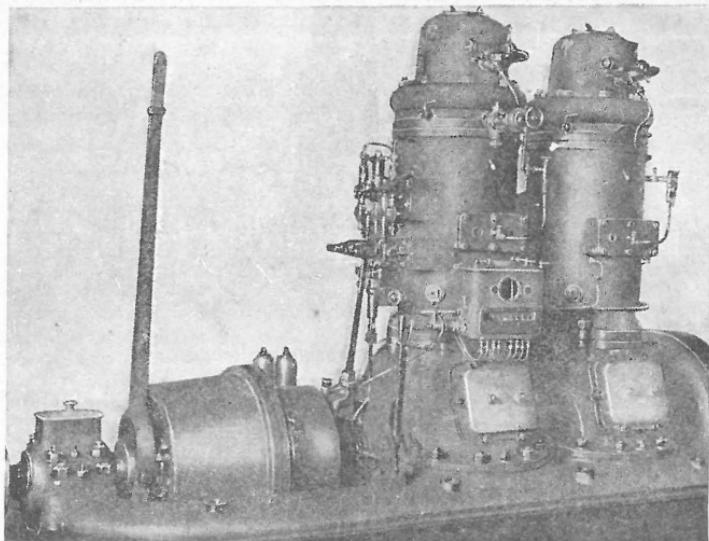
Reversing Engines

Strictly speaking, every two-stroke engine is reversible in the sense that it will run equally well in either direction, but it is not possible to obtain a quick enough reverse by stopping and then restarting by hand in the opposite direction. For this reason compressed air starting gear must be used unless the engine has electric ignition, in

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which case it can be stopped and restarted in the opposite direction by advancing the ignition fully and then switching on. This is done in the Day, Boulton and Paul and other two-stroke motors. With hot-bulb ignition it is not possible to reverse in this way except in an engine such as the Bolinders, in which "timing" of the ignition is decided by the moment at which fuel is injected into the cylinder.

It is possible to reverse a four-stroke engine provided the setting of the camshaft be altered, and this is done in one or two cases, notably in the Blackstone, Thornycroft, and Speedway engines. But compressed air for going ahead in the opposite direction and re-reversing, unless an electrical starter is fitted, is necessary.



The 1 .B.C. marine heavy-oil engine (hot-bulb type)—an example of Belgian design.

CHAPTER X

Care of the Machinery

THE complete machinery outfit of a motor boat or motor auxiliary may be divided under three heads:—

1. The engine.
2. Fittings, all parts, such as accumulators, coils, carburettor, water connections, fuel tank, piping, etc.
3. Transmission gear, by which the power of the engine is conveyed to the propeller, including clutch, reverse gear, and thrust block.

We will deal with each of these sections in turn, the object being not to point out what we consider the best kind of fittings, etc., for any particular purpose, but simply to enable anyone who has charge of a given installation to keep it in order, and, generally speaking, to make the best of it. At the end of each section will be found notes on the tracing of faults and their remedy.

I.—The Engine

A proper outfit of tools is absolutely necessary if an engine is to be properly looked after. A complete outfit of spanners, including a large and small shifting spanner, a pair of pliers, a hammer, large and small screwdrivers, a centre punch, an assortment of files, and a few wood-working tools, such as a bradawl, a gimlet or two, chisels, and a saw, are the most important, while a good vice fixed to a bench, however small, is a great convenience. In addition, there must be a set of spare valves, valve springs, a few piston rings, an assortment of spare bolts, screws, nuts, washers and split pins, besides two spare packings ready made to fit every packed joint on the engine. Naturally, oilcans will be included, and if there is any glass work, such as a lubricator, gauge, or sight feed, duplicates should be provided. Finally, cotton waste or suitable rags will be required.

As we are considering fittings separately from the engine, there will not be very much to say about the motor itself. The engine, and, of course, the engine-room or cabin, and everything in it, should be kept as clean and tidy as possible. Tools, etc., are best kept in a box or locker. The engine should be given a good wipe down after each run; all oil, etc., that may have been scattered about cleaned up; and exposed metal work, especially steel, given a coat of oil or vaseline. For this purpose a paint brush will be found very useful.

LUBRICATION.—The first care in every case must be for the lubrication. We have already described the various systems in use. It must first be found out exactly what method has been adopted, and every detail of it must be carefully studied before attempting to run the motor. Afterwards it will be necessary to run off all the oil from the crankcase occasionally, say, once a month if the motor is used much, and to start afresh with a new supply. Lubricating oil is expensive, and must never be wasted, but, on the other hand, damage done by want of oil will cost far more to put right than can be saved in oil consumption. Never buy lubricating oil that you do not know something about. Bad oil, even if it does no harm in other ways, may soot up an engine and make it necessary to take the cylinders off and clean the pistons. It is best always to ask the engine makers what oil they recommend, and carry an ample supply of it.

THE CYLINDERS.—Except when an engine is taken down for a clean up at the end season, the cylinders will need little attention. Compression cocks, if they show signs of leakage, may need taking up, and valve caps, which will have to be taken out if the valve requires renewal or adjustment, may need new packing or washers, but that is all. If the cylinder heads are separate, and it should ever become necessary to take them off, the greatest care should be exercised to prevent dirt getting into the cylinder, also the packing should be carefully looked to, otherwise there will be danger of water leaking into the cylinder.

HOT BULB.—If hot-bulb ignition be fitted, the bulb may have to be taken off and scraped now and then, or, possibly renewed. It will probably be found that the heat has set the nuts hard; if so, they should be soaked in paraffin and given a few hours to allow the paraffin to get well into them. After that they should move without much difficulty.

VALVES.—Should a valve break or warp, it will have to be replaced by a spare, and the spare must be ground on to its seating with emery and oil, a screwdriver being used to turn it. The grinding must be continued until the valve shows a bearing surface all the way round. Now, emery is fatal to bearings, so the greatest care must be taken to prevent any getting into the cylinder, and the best way is to stuff up the passage from the valve to the cylinder with a rag before commencing grinding. Afterwards the valve seating, and, indeed, the whole valve pocket, must be thoroughly washed out with paraffin and wiped quite clean. Occasionally, old exhaust valves become "pitted," and have to be ground in, but most people are much too fond of valve grinding; as a rule, an engine will go through a season without any grinding at all. The need for grinding is shown by loss of compression, and, if the valve be taken out, little pits or burns will be noticed on its seating. Valves are usually

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made "interchangeable" on an engine, but that really only means that all valves are the same pattern and dimensions. Each must be ground to fit its own particular seating, and so, if several valves are taken out at once, they must be marked and put back in their old places.

TAKING UP BEARINGS.—With long use, possibly every two years or so, bearings may require taking up, but that is not a job that the average man should tackle; at least, if he has enough experience to do it, there will be no need for him to read the subject up, so we will say no more about it.

PISTON RINGS.—Quite possibly such a thing will never happen, but piston rings do break occasionally, and, if so, must be replaced. This will mean either removing a cylinder or, if the heads are detachable, taking off the head, and also the big-end bearings, and drawing the piston and connecting rod together. The new ring must be carefully sprung into place, and the engine put together again. It is in this part of the work that most care must be taken. It is most important that the piston should be put back the same way round as before, otherwise the big-end of the connecting rod will come the wrong way round on the crankpin, and the oil scoop, if fitted, on the bottom of the brass would then become useless. In doing up the various nuts, great care must be taken to tighten all evenly. Never do one nut hard up before putting on the others. All should be set hand-tight first, and then each should be tightened half a turn at a time.

CAMSHAFT SETTING.—If for any reason it should be necessary to draw a camshaft, the gear wheels should first be marked with a centre punch to ensure their being put back in the same positions, otherwise it will be found that all the valves are set wrong. A mistake even of a single tooth may completely upset the running of an engine, so the marking should be so carefully carried out that there can be no possibility of a mistake.

TAKING UP WEAR IN THE VALVE TAPPETS.—This, again, is not likely to be necessary at all during a season, but in any case it is a simple operation. There is usually a screw adjustment and lock nut at the top of each tappet, and if there should be too much clearance between the tappet and the bottom of the valve stem, it must be taken up. Roughly, there should just be enough room for a slip of paper to be pushed between tappet and valve stem. It sometimes happens, especially on new engines, that the screw adjustment works loose, and so reduces the lift of the valve. A watch should accordingly be kept for this.

FREEZING OF WATER IN JACKETS.—If an engine is to be left standing for any time in a place where there is the slightest danger of frost, all water should be run out of

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the jackets, otherwise there is danger of ice cracking the cylinders, just as it cracks water pipes in houses. Some men leave the sea cock of the water circulation open, and if this is done the water may gradually leak out of its own accord past the pump, but it is never wise to trust to this. Again, the danger of freezing is far greater in fresh water, that is, on a canal or river, than at sea, because salt water does not freeze until a much lower temperature is reached.

Engine Faults

LOSS OF COMPRESSION.—This may be due to the piston rings, or more probably, to the valves wanting grinding. Complete loss of compression usually means that a valve is "hung up," that is to say, it may have jambed in its guide and may have to be freed with paraffin. Before assuming that valves or piston rings are at fault, make sure that, sparking plugs, valve caps, compression cocks, etc., are tight.

NOISE AND LOSS OF POWER.—If, after running for some time, a thud or ring comes from the engine, with a tendency to slow down, pre-ignition is probably the trouble, due to a carbon deposit in the cylinder. The cylinder must be removed, and its head carefully scraped clean, also the top of the piston. A hard, caked deposit is due to excess of lubricating oil, a soft, powdery deposit to too much fuel.

BROKEN PISTON RING.—Sometimes an engine may run with a broken piston ring without giving any signs at all of what has occurred; at others a terrible grinding noise may be heard, and directly this occurs the engine should be stopped and examined.

ENGINE HARD TO TURN.—Many engines are quite easy to turn when hot, but very stiff and difficult when cold. This is due to thickening of the lubricating oil, and may easily be got over by squirting a little paraffin into the compression cocks either when the engine is stopped or before starting up. Unusual and excessive stiffness, especially if accompanied by any "harsh" feeling, should be looked into more carefully. Probably it means that the pistons are not getting enough lubricating oil.

REFUSAL TO START.—This is nearly always due to one of four causes: (1) Valves hung up; (2) leakage of water into cylinder, either through a joint in the head or through a valve; (3) carburation; (4) ignition. In case (1) the valve must be freed with paraffin; (2) can easily be detected by removing a valve cap. If due to a joint, repacking will be necessary. If water has got in through the valves, the exhaust pipe is probably full of water, and must be drained. The cylinders must be cleaned with a rag, and may be finally dried by pouring in a *small* quantity of petrol, and setting a match to it. Faults in carburation and ignition are dealt with under their respective headings.

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II.—Auxiliary Fittings

The various fittings of an engine may be classed as follows:—

- (a) Carburetters, vaporizers and fuel pumps, piping and tank.
- (b) Ignition, hot bulb and electric.
- (c) Exhaust piping and silencers.
- (d) Water piping and connections.

We will deal with these in order:—

Section A.—Carburetters and Vaporizers, etc.

THE NEED FOR CLEANLINESS.—Almost every trouble that arises with carburetters is due to dirt. The fuel pipes, the needle valve, the passages leading to the jet, and, above all, the jet itself, are small, and liable to be stopped up by the smallest piece of grit. As we shall see later, a wire gauze strainer should always be used when filling a tank; there is often another strainer between tank and engine, and it is most important that dirt should never be allowed to get into the tank or into the carburetter itself. If this last is ever taken to pieces, care must be taken not to let any little pieces of dirt or of fluff off rags or cotton waste to remain inside it, for everything, sooner or later, finds its way to the jet and stops it up.

Very much the same remarks apply to the hand-adjusted needle valves sometimes used in vaporizers instead of float-feed spray systems; also to oil pumps when fuel is sprayed direct into the cylinder.

INDUCTION PIPING.—When, as is often the case, there is a length of piping between the carburetter or vaporizer and the engine, it may happen that a joint works loose. This means that an additional amount of air will be sucked into the engine, producing too weak a mixture, and making it very difficult to start. All joints should, therefore, be properly packed, and all nuts done up evenly and carefully, should the piping ever have to be taken down.

FLOODING OF CARBURETTER.—Occasionally, carburetters have to be flooded, and, as so doing causes petrol or paraffin to drip from them, it is dangerous to let fuel get into the bilge in this way, and a trough or tray, if possible, covered with wire gauze, should always be kept beneath the carburetter and emptied daily.

FUEL TANK.—Fuel tanks should be examined from time to time, especially at joints and pipe connections. The place where they are kept should be well ventilated, and lights should not be brought near unless one is perfectly certain that there is a good draught of air, and that there is no leakage.

FILLING A TANK.—Filling should always be done through a gauze strainer or funnel, and at least half as much fuel again, or, better still, twice as much as is likely to be

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required, should be carried. Particular care with regard to ventilation and lights is necessary when filling is going on. Remember that fumes will hang about for hours afterwards, unless there is enough draught to blow them away.

AMOUNT OF FUEL REQUIRED.—It is a fair working rule to allow a gallon of fuel an hour for a 10 h.p. engine, half a gallon for a 5 h.p. engine, two gallons for 20 h.p., six gallons for 60 h.p., and so on. Now, supposing we have an eight-knot boat, and that she has to go to and from a fishing ground 80 miles away. She will take about 10 hours each way, that is, 20 hours altogether. If her engine gives 50 h.p., she will use 5 gallons an hour, or 100 gallons for the return trip. At least 150 gallons should, therefore, be carried to allow of foul tides or bad weather. As a matter of fact, it is always well to be on the safe side, and fill up with fuel whenever possible. A 50 h.p. heavy-oil engine would use about $3\frac{1}{2}$ gallons per hour.

PRESSURE AND GRAVITY FEED.—In big boats the main fuel tanks are generally below the level of the engine, so there is usually a smaller running tank placed above engine level, and supplied by a hand pump from the main tanks. The feed from the running tank to the engine may be by gravity, but unless the tank is amply high enough there is a chance of the fuel failing to reach the carburetter when the boat is pitching about.

Sometimes pressure feed is used instead. In this case there is either a small air pump driven off the engine, which keeps a pressure of one to five pounds to the square inch in the petrol tank, or the exhaust pressure is utilized, a small by-pass pipe from the exhaust being led into the top of the fuel tank. This pipe is occasionally found to become sooted up, and should, therefore, be taken down and cleaned out once a month or so.

FUEL PIPES.—A fuel pipe should be touched as little as possible, but whenever it is necessary to disconnect a joint, the very greatest care should be taken that it is made quite tight again.

TURNING OFF FUEL.—However certain you may be that the float feed of the carburetter or vaporizer works perfectly, make it a rule always to turn off the fuel supply whenever an engine is stopped. Also, if a stop is to be made for more than a few minutes, the pressure should be released from the tank when pressure feed is used.

STARTING WITH PRESSURE FEED.—When starting up, do not forget to pump up pressure by hand in the tank. There can be no exhaust or air pressure when the engine is not running.

CLEANING THE FILTER.—There is nearly always a strainer or filter between the fuel tank and the engine. However much care is taken with regard to dirt, a little is certain to get into the tank, and in time to the filter. Do not wait for the filter to become choked, but make a rule of cleaning it, say, once a week or once a fortnight.

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Faults

"POPPING" AND DIFFICULTY IN STARTING.—Usually a sign that the mixture is too weak. See if the jet and pipes are dirty, also the filter, and, if pressure feed is used, make sure there is enough pressure. Also make sure there is no leaky joint in the induction piping where air can get in.

FLOODING OF CARBURETTER.—The needle valve may want grinding into its seating, or, possibly, the float is punctured. It is made of very thin metal, and is sometimes damaged in this way. If so, carefully drain out all fuel, and solder the hole, using as little solder as possible, as an increase in weight of the float would raise the level of the fuel in the float chamber, and allow too much fuel to pass.

SMOKY EXHAUST.—This may be caused by the bulb being too cold when hot-bulb ignition is used, but otherwise is due to too much fuel or over-lubrication. Examine the top of a valve or a sparking plug. If there is a fine, black powder deposit, there is too much fuel, that is, too "rich" a mixture, and the extra air valve must be opened more, or the fuel supply reduced. If there is a hard, caked deposit in the cylinders, it is due to excess of lubricating oil, and the remedy is obvious.

IRREGULAR RUNNING—WATER IN FUEL.—Unless the ignition is at fault, this is almost always due to a choked jet, or to water in the carburetter. A glance inside the float chamber will betray the presence of water, which remains quite separate from petrol or paraffin, and will be seen at the bottom of the chamber. When water is present, drain the carburetter, disconnect the fuel pipe, and run off until there is no longer any sign of water.

DAMAGE TO JET.—It takes very little to alter the size of a jet, so, if dirt has to be cleared by means of a needle or some such instrument, the greatest care must be taken not to use any force. The smallest alteration in a jet may entirely upset the running of an engine.

Section B.—Ignition Arrangements : Ignition, Hot-Bulb

There is no need to say very much about hot-bulb ignition, as the bulb itself was mentioned as an integral part of the engine. The chief point is to make sure of getting the right temperature at the start, and a very few days' experience will be enough for this. During a long run at full load, there is occasionally a tendency for a bulb to overheat, producing pre-ignition, which can easily be detected by a heavy thump from the engine. The remedy is to take the cover off the bulb, and so give it a chance of cooling slightly. On the other hand, if an engine has to run slowly for some time the bulb sometimes becomes too cold, in which case the engine will be sluggish and give very little power. If there is any sign of this trouble the blow-lamps should be lit and used to bring the bulb up to the right heat.

Electric Ignition

Of all electric ignition systems, it may be said that the most important thing is to keep everything perfectly dry and clean. As regards other details, we will first of all consider high-tension electric ignition. The accumulators never give any trouble if they are properly looked after, but neglect is fatal to them. Be careful never to spill acid out, and if, owing to evaporation, the level of acid in the cells falls below the top of the plates, the loss should at once be made up with water. Never completely discharge an accumulator, and even after only a little current has been taken out of it, never lose an opportunity of charging up fully.

Accumulator terminals are always apt to become corroded by the acid, and should therefore always be kept well greased.

Induction Coil

As an induction coil supplies high-tension current, it is specially important that it should be kept perfectly dry, and, it should be installed in some position in the engine-room where it will be well protected from all chance of getting wet, in a position where it will be warm, but not too hot: for example, it would be good to keep it within a foot or so of the cylinder jackets, but it should not be near the exhaust nor should it be underneath any water joint, in case water should drip on to it.

There is only one repair that the average engineer should ever attempt to make to an induction coil, and that is to adjust the trembler; this will need doing from time to time, and in the ordinary way a coil should last for years without any other attention. To adjust the trembler the set screw should be taken out and the contact point, both on it and on the trembler blade, cleaned and squared up with a very fine file. The trembler can be set to give a good buzzing note and made fast with the set screw.

Switches

There should always be a switch somewhere in the low-tension circuit. This should be looked to now and then to make sure that the contacts are clean and that no water has collected in it. The presence of water in a switch will often make no difference to the running of the engine, but it may mean that, when the ignition is switched off, a leak is always going on, with the result that the accumulator may be found discharged when it has scarcely been used at all.

Commutator and Distributor

The commutator and high-tension distributor, if used, should be cleaned occasionally and kept slightly oiled, and the make-and-break connections of the commutator should be kept specially clean, for they are quite as important as the trembler of the induction coil.

CARE OF THE MACHINERY

Sparking Plugs

The sparking plugs should be taken out and cleaned occasionally. Nothing is better for this purpose than an old toothbrush, and a little petrol will be found to make the cleaning much easier. Attention should be given to the length of the spark gap, which should be about equal to the thickness of one's thumb-nail.

Plugs are often in rather an exposed position on an engine, so care should always be taken to protect them from wet in every possible way.

Wiring

All wires for connections should be always carefully treated ; they should be kept clean and dry and quite free from oil. Moreover, care should be taken never to kink them, as so doing may cause a break in the wire very difficult to locate. To save trouble, engineers sometimes are contented simply to bare the ends of wires when making connections, but it is always much better to connect them to a proper terminal, which can be bought by the dozen for a few pence. A supply of insulating tape should always be kept handy for binding round joints in wires, etc. Finally, all wires should be marked in colours, or with figures to correspond to the cylinders to which they belong. Unfortunately, makers of engines do not often trouble to do this, but it will be worth the while of any engineer to spend half-an-hour in doing it for himself, as it prevents the possibility of mistake in making connections afterwards.

Low-tension Ignition

A magneto is always used with low-tension ignition, so we will say nothing about solenoids here, and the only part that will need attention will be the make-and-break inside the cylinder, together with the single wire and its branches leading thereto. The whole should be kept as dry as possible, and all springs and external metal parts well oiled, otherwise they may become stiff in action. Often the trip gear will run for months without any other attention, but occasionally it happens that a little loss of compression occurs past the rocker arm passing into the cylinder, which may have to be taken up ; also the contact points occasionally want filing up square with a very small fine file or emery paper, and adjusting.

Magnetos

Both high-tension and low-tension magnetos may be taken together. The great thing to remember is to keep them dry and protect them as far as possible from dust and grit, otherwise the golden rule is to leave the magneto quite alone ; it very seldom gives any trouble, but if any derangement should occur, it will almost certainly have to be dealt with by an expert. Ball bearings are nearly always used, they should be given a drop of oil only every

now and then ; ordinary lubricating oil is very often used, but castor oil is really better. It is a great mistake to overlubricate a magneto, as the oil only gets on to the armature and damages the insulation. Practically speaking, nothing else should ever be attempted with a low-tension magneto, but with a high-tension it is necessary at long intervals to adjust the make-and-break.

Adjustment of Make and Break

This is a delicate job, and too much care cannot be taken over it, for, in the first place, the parts are small and easily damaged, and, in the second, a very small error in adjustment is enough to upset the running of the magneto entirely. When the points do have to be set they should be thoroughly cleaned, and so arranged that when the circuit is broken the gap between them is about half the usual spark gap of an ordinary sparking plug.

Coupling Up a Magneto

It is often necessary to uncouple the magneto from the engine when this is done, but before doing so the setting of the armature relatively to the engine should be carefully marked with a centre punch. There is usually a jaw or coupling piece between the armature and the engine, and this also should be marked, as shifting it round often has the effect of advancing or retarding the ignition.

A magneto, as we stated some time back, usually gives two sparks per revolution, so that with a four-cylinder four-stroke engine it will be run at crankshaft speed. Its distributor, however, is only turning at half engine speed, so that, though the armature may be set in the right position relatively to the engine, the distributor may be half a turn out. For this reason, when disconnecting the magneto, it is not enough to mark only the armature : the position of the distributor also should be carefully noted, and when replacing the magneto it should be turned until the distributor is in the right place before attempting to fit it to the engine.

Timing

If these instructions are carefully followed out the engineer will not have to time his magneto at all, but in case any mistake should be made and the correct position lost, the engine should be turned until it is at the top of a dead centre and one of the cylinders (we will assume No. 1) about to fire. The magneto must then be turned until the distributor shows that current is being supplied to the terminal usually connected to No. 1 cylinder. Then the armature must be turned slightly backwards and forwards, keeping an eye on the contact breaker. The moment that the circuit is broken is the one at which the spark is produced, and so, when the armature is moved just to the point of break, it must be coupled in that position to the engine, which is at the dead centre, or perhaps slightly in

CARE OF THE MACHINERY

advance of it, according to whether the ignition is advanced or not.

Exposure to cold, damp air.—If the engine is to be out of use for any time it is good practice to disconnect the magneto and put it in a warm room for a few days, which will have the effect of thoroughly drying all moisture out of the armature.

Lining Up

It will often be found that the magneto has been lined up with the engine by means of thin packing plates on which it rests. If any of these are used, care should be taken not to lose them, and they should be replaced carefully in their original position.

Testing the Spark

As already stated, a magneto very seldom gives any trouble, but if it is suspected that anything besides the make-and-break is wrong, it is easy to test it in the following way: the metal part of a screwdriver or spanner should be placed on top of the steel magnet and the other end brought within a quarter of an inch or so of one of the distributor terminals. Assuming the magneto to be a high-tension machine, if the armature is turned sharply by hand a good thick spark should be obtained. If no such spark occurs there is probably something wrong and the magneto should be sent to an expert.

Faults—Difficulty in Starting

In the case of accumulator ignition, this may be due to the accumulator wanting charging. In a magneto it may show that the contact points want adjusting. With high-tension ignition it is far more probable that the plugs themselves are at fault. They should be taken out and examined, and, if dirty, cleaned, preferably with a tooth-brush and a little petrol; also make sure that the porcelain or other insulation is not cracked or loose. Be careful also to replace the copper asbestos washer underneath the plug. In damp weather an engine should be turned round as little as possible with the ignition switched off; so doing draws in damp air, and water is liable to condense on the plugs, making it impossible to start. When this occurs the plugs must be taken out. The best way of thoroughly drying them is to put a few drops of petrol on each and set light to it, but be careful not to do this where a fire can possibly be started.

How to Detect an Ignition Fault

An absolutely sudden stoppage while running may usually be put down to ignition trouble of some sort, or if one cylinder suddenly misses fire, that also is almost certain to be ignition—probably a dirty plug. It is easy to tell if the fault be in the high-tension or low-tension side when accumulator ignition is used. If a spark can be obtained at any

one of the plugs it is a sure sign that the low-tension side is all right and that the fault lies in one or more of the high-tension connections of the other cylinders. If no spark can be obtained at any cylinder it is possible that the high-tension distributor, if used, is wet or otherwise deranged, but far more probably it is the low-tension side that is at fault: possibly a trembler may need exhausting, the commutator may be dirty, a wire broken, or the accumulator run down.

What has been stated about high-tension magnetos will be enough to show where to look for trouble in them. It may, however, be mentioned that most engineers are far too ready to blame the magneto for any little trouble that may arise; the fault is much more likely to lie somewhere else. With low-tension magneto ignition practically every derangement is due to the trip gear, which should be looked over to see that all springs, etc., are all right. If no fault is found there the contacts must be taken out of the cylinder, cleaned and adjusted.

Section C.—The Exhaust Piping and Cylinder

When fitting out a boat at the beginning of the year, it is usual to take the cylinder and exhaust pipes to pieces for a thorough clean, but in the ordinary course of events the exhaust arrangements of an engine should go right through a season without any attention whatever. The only possibility of trouble lies in the blowing of a joint, which may have to be re-packed with asbestos or millboard. Nuts on the exhaust piping will very likely have set hard and will have to be freed with paraffin in the way already explained in reference to hot vaporizer bulbs.

Section D.—Water Circulation

Here again it is probable that a whole season will pass without any attention being required. We have already explained that the great danger lies in weeds or mud choking the inlet, but with a good type of filter it is only a matter of seconds to clear the obstruction away. After a day's run the sea-cock should always be turned off to prevent any possible risk of a leak starting at some other joint. Do not forget, however, to turn the cock on again before starting up. Priming in a well-designed circulating system should never be necessary, but a day or two's experience will show if it is required with the engine that the reader has to run. If the water outlet is above water level a glance at it after starting up will show if water is coming through, otherwise it is well to feel the cylinders after a minute or so to make sure that they are not unduly hot.

All points in water piping are best screwed and coned, but, in some cases, rubber connections are unavoidable. Where these are used an ample supply of spares should be carried. The danger of water freezing in the jackets and causing a crack has already been referred to, so need not be dealt with again here.

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Transmission Gear

THE CLUTCH.—Very little attention will be needed by the rest of the installation. First we will consider the clutch, which, if it shows signs of fierceness, may be oiled *slightly*. Too much oil produces slip, and the only remedy is to wash out thoroughly with paraffin. There is, however, no reason why a clutch should not go right through a season without any attention at all. Make it a rule, when shutting down, always to leave a clutch in engagement; if left "out," unnecessary pressure is put on the spring, and there is risk of water getting in and damaging the clutch surfaces.

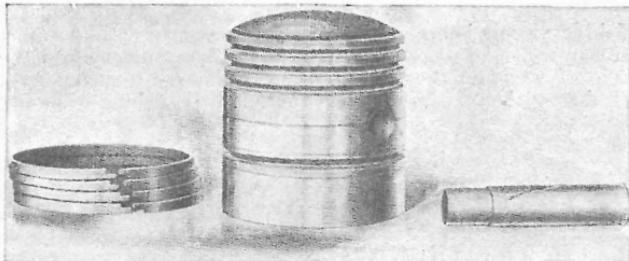
UNIVERSAL JOINTS, if fitted, should be oiled occasionally.

THRUST BLOCK.—Particular care should be taken to keep the thrust block, if separate from the gas engine, well lubricated.

REVERSE GEARS.—Nearly all gears are completely enclosed and run in a bath of thick oil, requiring no attention at all. Clutches, when combined with the gear, must be treated as described above.

REVERSING PROPELLERS.—The only attention likely to be required is lubrication of the thrust blocks and sliding gear.

STERN TUBE.—With use the stern-tube gland may develop a slight leak; if so, it must be tightened up, or in bad cases repacked. It may, in fact, be regarded in exactly the same light as the stuffing box of a steam engine.

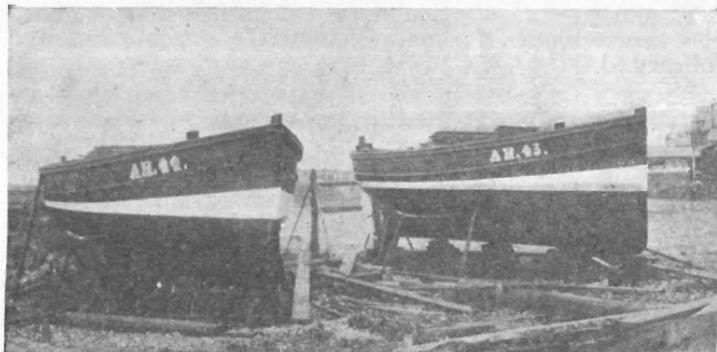


A piston, piston rings, and gudgeon pins of a marine motor.

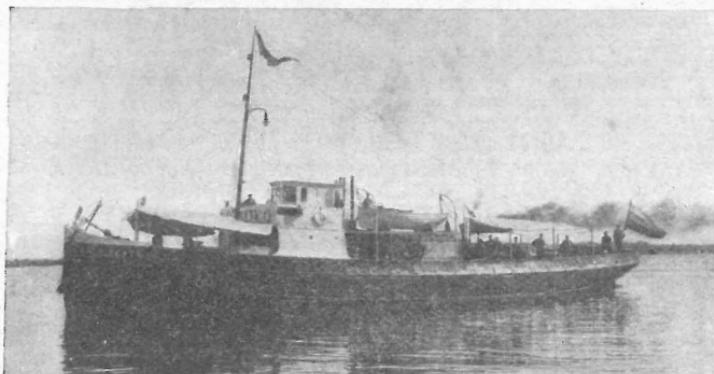
MARINE OIL ENGINE HANDBOOK



A large twin-screw Russian passenger motor ship. This vessel is driven by two 600 h.p. four-stroke type Diesel motors, and has a speed of about 14 knots. The short funnel, which is used for ventilating the engine room, and for carrying away the exhaust gases, gives her the appearance of a steamer.



Two fishing vessels being converted to motor power. The drawback to the conversion of existing craft is that they must be laid up for a couple of weeks, but this can be overcome by carrying out the work during the off season, when there is little fishing to be had.



A powerful twin-screw motor tug and ice breaker. She is fitted with two 180 h.p. Polar-Diesel two-stroke oil engines, and has a speed of 12 knots. The absence of a large funnel considerably improves her appearance.

CHAPTER XI

Marine Heavy-oil Engines

Examples of the Leading Hot-bulb Types

ALTHOUGH the marine heavy-oil engine of the hot-bulb type has been constructed for many years, both for marine and stationary purposes, it was not until the advent of the large Diesel-driven motor ship that it sprang into prominence in this country. Among fishing craft, etc., in Scandinavia and several other Continental countries its use in commercial craft was very general in the past. The marine type is now, however, constructed in Great Britain by just over a dozen different firms, and considering that there are only 40 different makes all told, disregarding land models, the percentage is quite good. For about a year this class of engine was generally known as the "Semi-Diesel," but lately it has fallen back into its proper nomenclature of hot-bulb heavy-oil engine.

In design this engine is quite distinct from the Diesel, inasmuch as the heat necessary for combustion is obtained artificially, whereas the heat is generated purely by high compression in the case of the Diesel. The compression of most hot-bulb motors, particularly those of the two-stroke class, is in the neighbourhood of 150 to 200 lb. per sq. in., compared with 450 lb. for the Diesel. Also, in the latter case, fuel injection and pulverization is assisted by an air blast of 800 lb. to 1000 lb. per sq. in. pressure.

With the type under discussion, the fuel is injected by a small plunger pump to each cylinder, the fuel entering a heated chamber, termed the hot-bulb, and on the compression stroke is automatically fired. A blow-lamp is required for starting and when running at half-power, the heat of the explosion being quite sufficient to keep the bulb hot once the engine is running on full load. With a few designs, however, compressed air injection has been introduced, but this is the exception rather than the rule, and tends to complicate the construction and increase the cost. Water drip is also used with some makes, but several makers are now dropping this system, and only fitting it when specially desired by the purchaser. Its adoption means that large fresh-water tanks have to be carried. Water cooling of the bulb is now becoming the general system in its place, as this requires no fresh water.

The hot-bulb motor is generally of the slow-running type, and is heavily constructed, the speed usually varying from 200 to 500 revs. per minute, according to the power. Consequently, it is principally adopted for commercial craft,

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such as barges, fishing boats, auxiliary schooners, tugs, lighters and coasting cargo vessels; but where weight for power is not an important consideration, it has been found very valuable for motor yachts. By reason of the moderately heavy oils that can be used, such as gas oil, gasoleum, low-grade paraffin, and even solar oil, it is a most economical engine to run, hence its popularity among the owners of commercial craft, where the running has to show a reasonable profit. Also the slow revolutions allow good propeller efficiency to be obtained with a heavy boat, or where the thick deadwood aft would obstruct the proper flow of water to a small and fast turning propeller. In some cases the latter difficulty has been overcome by the use of reduction gearing, but this, while excellent in special cases, is hardly to be advised for general purposes, as it is not economical from a fuel consumption per shaft horse-power point of view. We now propose to give brief details of the leading British and Continental makes of marine hot-bulb engines. There are, of course, others, but the limited space at our disposal prevents our dealing with them all. Those dealt with, however, will give a good idea of the general practice and design now in vogue.

Regarding the question of sizes, the smallest yet made for commercial purposes is 3 b.h.p. and the largest 500 b.h.p., while the most important installation is two engines of 340 h.p. in a twin-screw vessel. It is not likely that many ships will have greater power than this, as from 500 h.p.



Photo by courtesy of]

[Norris, Henty and Gardners, Ltd.

Motor-driven fishing boats making for port under power with their catches. Note the sailing boat well astern.

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upwards the fuel consumption of the pure Diesel engine makes the adoption of the latter more desirable.

In connection with the fuel consumptions of hot-bulb engines, there would be a tendency to overrate the economy. Once an engine is installed in a vessel, there is very considerable difficulty in estimating the actual brake horse-power hour consumption of an engine owing to it being almost impossible to tell exactly what power is being developed at certain revolutions. To give an example. On the test bed an engine has a carefully-checked consumption of, say, 0.55 lb. per b.h.p. hour, when developing its rated power of 50 h.p. on the brake at 300 revolutions per minute. After installation, it is quite possible that the fuel consumption at 300 r.p.m. is down as low as 0.45 or 0.50; but it does not follow that the engine is more economical, as, although the engine is still turning at the same speed, it is most likely that the power developed is less, due to an incorrect propeller, yet, at the same time, the boat may be maintaining her guaranteed speed, as makers nearly always allow a margin of a few horse-power when designing a vessel.

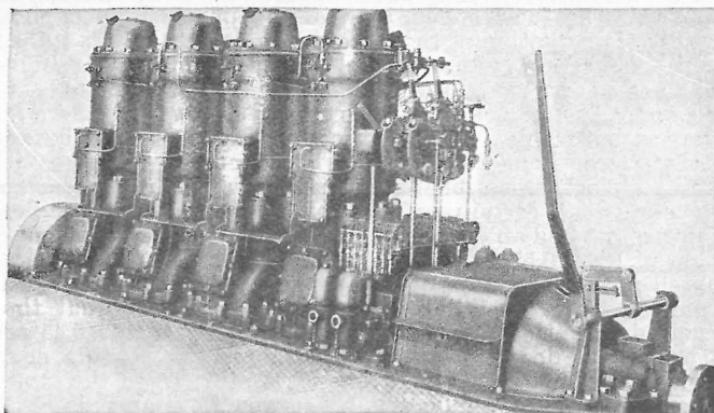
At the recent Copenhagen Exhibition (1912), a number of hot-bulb marine oil engines underwent severe tests, including that of fuel consumption, and the results obtained make an interesting table.

Engine.	Type.	Brake horse-power developed.	Revs.	Bore.	Stroke.	No. of cyls.	Oil.	Consumption per b.h.p. hour.
Avance ...	2-stroke	45.8	242	14 ³ / ₈	14 ¹¹ / ₂	1	Russian Solar	lb. 0.548
Bolinders	2-stroke	82.6	329	12 ¹¹ / ₈	13 ¹ / ₂	2	Alfa Solar	0.547
Tuxham	2-stroke	28.6	454	7 ³¹ / ₄	9 ¹ / ₂	2	E.O.G. Solar	0.563
Hein ...	4-stroke	10.1	376	7 ³ / ₄	10 ⁵	1	Russian Solar	0.726
Hexa ...	2-stroke	10.8	483	7 ³¹ / ₄	8 ³ / ₄	1	Kraftogen Solar	0.908
Dan ...	4-stroke	11.0	357	9 ¹¹ / ₁₂	11 ¹ / ₂	1	Alfa Solar	0.924
Volund ...	2-stroke	8.6	465	6 ³ / ₄	8 ⁷ / ₈	1	Alfa Solar	0.700
Gideon ...	4-stroke	10.9	390	7 ³ / ₄	11 ¹ / ₂	1	Russian Solar	0.865
Original	2-stroke	17.7	353	9 ³ / ₄	9 ³ / ₂	1	Alfa Solar	0.592

So it will be seen that, on actual official tests, every engine had a consumption of over 0.54 lb. per b.h.p. hour; but it must be taken into consideration that most of them were of small powers, and with larger motors the consumptions are no doubt somewhat less. We now deal with the noteworthy features of typical hot-bulb engines as follow:—

The Bolinders

In the Bolinders we have one of the comparatively few direct-reversible engines, and although compressed air is required for starting, it is not made use of for reversing, this being accomplished by causing the striker of the fuel-

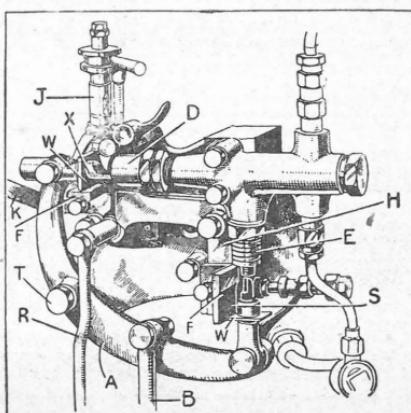


The Bolinders engine.

pump plunger to jump on a stepped guide, and thus miss the wedge of the plunger, and so no fuel is injected. Consequently, the engine slows down. As the speed slackens a charge of fuel is automatically injected from an auxiliary pump on the up-stroke of the piston, which causes a backfire, and incidentally reverses the motion of the crankshaft. Immediately this takes place the main fuel pump comes into action again.

Re-reversing is accomplished in the same manner, while governing is also carried out by the jumping of the pump striker when the speed gets excessive—for this there is a spring regulator. The engine is of the two-stroke class, and is made in sizes varying from 10 h.p. at 600 r.p.m. to 320 h.p. at 225 r.p.m. It is constructed in Sweden and marketed in the British Isles by Messrs. Pollock, Sons, and Co., Ltd. of London.

The governing and reversing mechanism can better be followed in co-operation with a sketch. Practically all this gear is arranged at the after-end of the engine, and is actuated by a rod (B) from an eccentric on the crank-shaft extension. The main fuel pump can be seen at D, and it is operated by a hit-and-miss action from the rocker arm (A), the latter swinging on the fulcrum (T), and rocked by the rod (B).



Fuel pump mechanism.

At the upper end the rocker arm is loosely swung, the striker (X) which works the main fuel pump (D). This striker is fitted with a squared ebonite guide (W), which slides on the stepped saddle (F). Should the engine speed increase above the normal, the step (F) causes the guide to jump; consequently, the striker passes over the plunger of the fuel pump, and thus a fuel-injection stroke is missed.

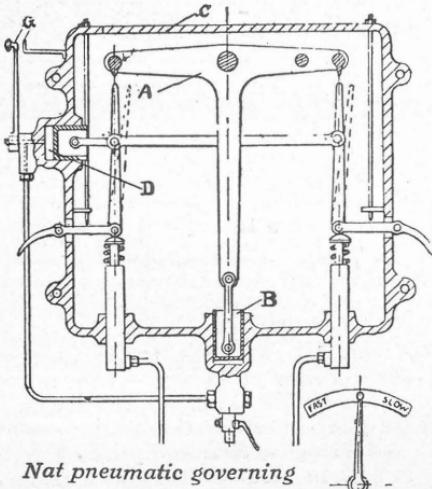
When reversing, fuel is cut off by moving the lever (J) and so decreasing the pressure on the loosely-swung striker (X), thus causing it to jump freely at the step. As the engine slackens down a charge of fuel from an auxiliary pump (E) is injected on the up stroke of the piston, causing a backfire and forcing the piston down again and reversing the motion of the crankshaft. To bring the auxiliary pump, which is worked by the lower end of the rocker (A), into action, a hand lever is moved forward. Its lower end is fitted in a friction shoe running loosely on the crank-shaft extension, and moving the lever tends to jam the shoe on the rotating shaft. The friction raises the rod (R), which also is attached to the shoe, and at its upper end is secured to the bracket containing the stepped saddles of the main and auxiliary fuel pump strikers, the former is raised clear and the latter brought into action.

One fuel charge from the auxiliary pump is sufficient to reverse the motion, and the friction on the shoe is then released automatically, and the main pump resumes its work, as its striker automatically falls back into position.

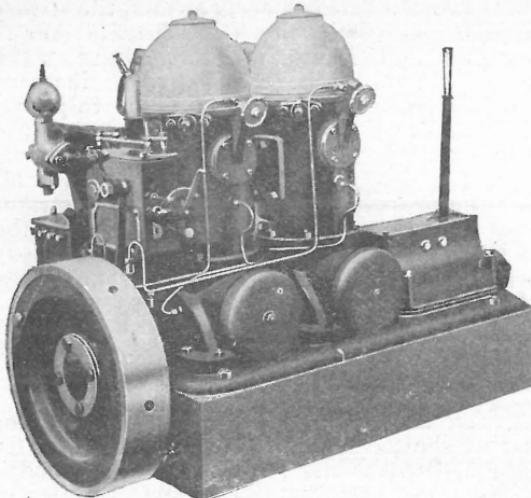
The Nat

Although only put on the market several years ago, the Nat engine at the outset embodied the latest improvements of the two-stroke type of heavy-oil engine, yet various little details of the design are constantly changing.

It is made by the Torbinia Engineering Co., of London and Lowestoft, and is of the non-reversible class up to 100 h.p., with direct reversing arrangement from that power to 320 h.p., the latter being the largest model designed. It is of the three-port type, with crankcase compression, and the latest engine shows some very novel features in connection with the fuel pump operation and governing gear.



Nat pneumatic governing gear.



*The
Nat
engine.*

The governor of the fuel pumps is of the hit-and-miss type with a special pneumatic control, and reference to the drawing will show the operation. The bell-crank (A) is connected to an eccentric on the crankshaft by means of a rod, which, when in motion, oscillates the bell-crank backwards and forwards and up and down, thus giving the air-pump plunger (B) two strokes for each revolution of the crankshaft. This air pump (B) is connected by means of a small pipe (D), which has a piston fitted and is coupled direct to the striker, so that when the piston in the cylinder (B) has accomplished its full stroke, it has forced a charge of air into the small cylinder at D, at the same time forcing the strikers out, as shown dotted. The air in the small cylinder (D) has to escape entirely before allowing the strikers to regain their original position, so that the striker-pin fixed to the rocker can hit the striker and work the fuel pump. Should the engine run too fast, the rocker will get down before the air has been allowed to escape through a control wheel fitting on to G, and, in consequence, it will miss the striker, and so stop injection of oil into the working cylinders. The control is operated by the handle (G), and this regulates the speed of the air escaping from the cylinder (D) after being charged at the exact moment from the cylinder (B).

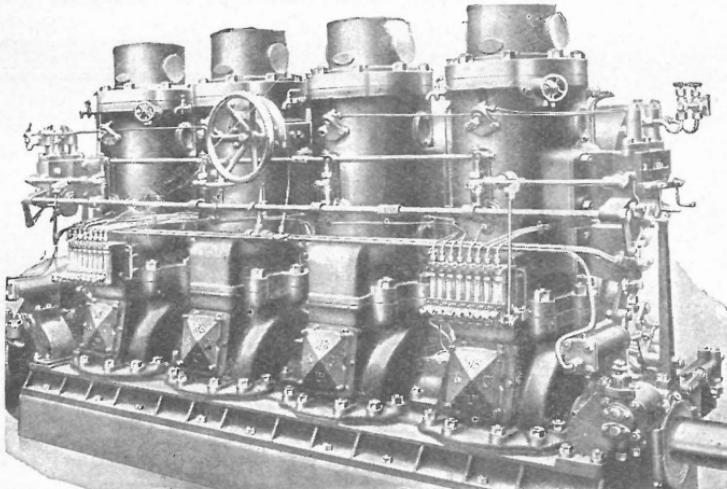
The Beardmore

The Beardmore engine is of the two-cycle type, and is manufactured with one, two and four cylinders. The four-cylinder engines are direct reversible, and, consequently, require no clutch or reverse gear between the engine and propeller. Starting and reversing are accomplished by means of compressed air stored in steel bottles, and these are kept fully charged by the explosions in the engine

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cylinders, so that an air compressor is only required for emergencies. The engine is started, stopped, reversed and completely controlled by a single hand wheel placed in a convenient position at the front. Bilge and circulating pumps are fitted, the latter supplying water for cooling cylinders, cylinder covers and exhaust silencers. Large doors are provided at front and back for access to crankpin bearings, the pistons and connecting rods can be drawn upwards by removing the cylinder covers, and the main bearing bushes can be removed without disturbing the crankshaft.

For fuel injection, a separate fuel pump of the plunger type is provided to each cylinder, and these are operated by eccentrics on the crankshaft. Lubrication is by force sight-feed, except in the case of the bearings, where wick



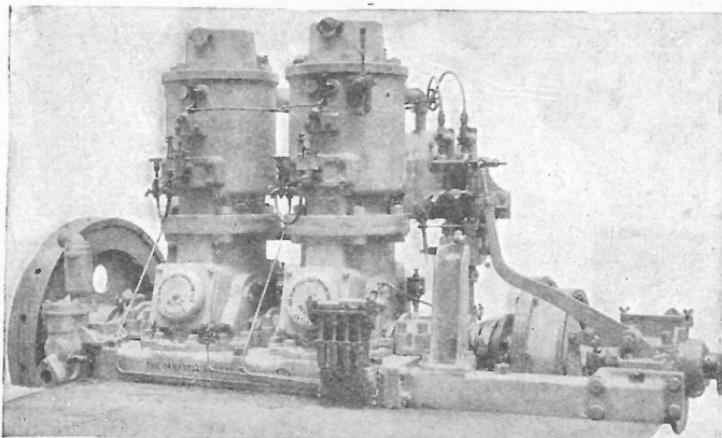
The Beardmore engine

syphons are used. The makers state that the engine will run on any quality of fuel ranging from ordinary paraffin to the heaviest residue oils, and the consumption is about 0.6 pint per b.h.p. hour. The working of this engine follows the usual practice in that, on the up stroke of the piston, a supply of air is drawn into the crank chamber through specially-designed non-return valves, while above the piston compresses the air into the combustion chamber. When the piston reaches the top of its stroke fuel is injected directly into the lamp-heated (for starting only) combustion chamber, where it is immediately ignited, and causes the downward or power stroke. On the down stroke the air in the crank chamber is compressed in readiness for scavenging purposes. When the piston is nearing the bottom of its stroke the exhaust ports are uncovered, and the exhaust gases escape into the water-cooled silencer,

and an instant later the scavenging ports are opened and compressed air from the crank chamber sweeps the remaining burnt gases out of the cylinder. This engine is built by Wm. Beardmore and Co., of Dalmuir.

The Campbell Engine

The Campbell engine is of the directly-reversible type, reversing being accomplished either by pre-ignition in the ordinary way, or by means of compressed air. The latter method is generally used when the power exceeds 100 h.p. Water injection is employed, the supply being taken from the cylinder jacket cooling water and admitted through an automatic valve, which is opened by the suction in the cylinder. The supply can, if desired, be controlled by hand by altering the tension of the spring in the valve. In the engine in which the pre-ignition system is adopted for



The Campbell engine.

reversing, the fuel pump is driven from a loose eccentric, which is retarded 180 degrees when it is required to go astern. By this means the fuel is injected at the right point for reversal.

When compressed air is employed for reversing, an ordinary arrangement of ahead and astern cams on a single camshaft is adopted, the camshaft being moved longitudinally when reversing. These cams operate small plungers in distribution boxes, which control the supply of compressed air to the cylinders. Lubrication is carried out by a series of small plunger pumps driven through a small eccentric on the crankshaft, although sight-feed lubrication may be adopted when required. The plungers can be operated by hand to give extra oil to any particular bearing should this be necessary.

In the air reversing engine a small air compressor is

HEAVY-OIL ENGINES

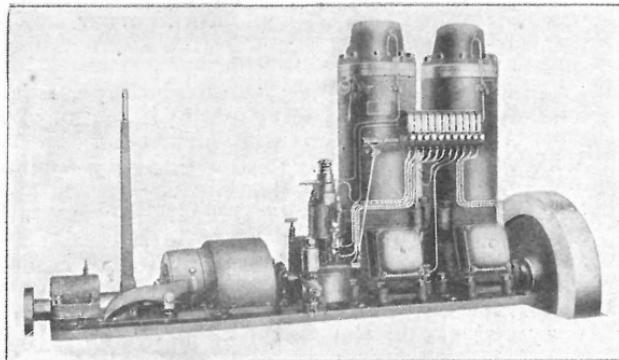
driven directly off the crankshaft by means of an eccentric, whilst in all types of engines the water-circulating pump is driven off the motor itself. This compressor only supplies the air for reversing, a separate reservoir being provided, which is charged by combustion for starting purposes. The governor is of the hit-and-miss type, and regulation down to half speed is conveniently obtained by a small hand lever. The speed of the engine is normal, being 375 r.p.m. for a 20 h.p. single cylinder. The crank chamber compression is about 7 lb. per sq. in., and the compression in the cylinder itself is about 150 lb. per sq. in. The fuel consumption is about 0.6 pint per b.h.p. hour, the most suitable being gas-oil and similar grades.

The engine is built by the Campbell Gas Engine Co., Ltd., of Halifax, and handled by Messrs. Mortimer and Bacon, of London, E.C.

The Skandia

Another engine of the heavy-duty type is the Skandia. In company with other engines using heavy oil, the fuel charge is injected into the cylinder head by means of an oil pump and injector. The engine works on the two-stroke principle, and the air supply reaches the combustion head via the crankcase in which it is compressed. From 5 h.p. to 80 h.p. a reverse gear and clutch are fitted, whilst three and four cylinder models from 40 h.p. to 200 h.p. are direct reversible on compressed air from a separate compressor coupled to the motor. Owing to the fact that pure air only is compressed in the crank chamber, there is no possibility of a back-fire in this part. The general design of the engine is very simple, and this feature, coupled with the strength of construction, should render the Skandia engine particularly suitable to perform the work demanded of a commercial motor.

The fuel consumption of oil having a specific gravity of



The Skandia engine.

0.825 averages 0.7 pint per b.h.p. hour, varying according to the power of the engine. The manufacturers are the Skandia Works, Ltd., of Lysekil, Sweden, and the English agents Messrs. Greenhalgh, of London and Manchester. As is usual with this type of engine, crankcase compression and ports are employed for scavenging, the piston being of special lip shape to facilitate this, and the general working arrangements correspond, of course, with modern practice, and so need not be dealt with here. Each hot-bulb is fitted with a burner for starting purposes, the oil retainer being mounted on the crankcase bed at the after-end of the engine, while the oil is fed by pressure from a small hand air pump integral with the reservoir.

At the after-end of the engine is a neat pedestal, and this contains the fuel pumps, which are of the plunger type, also the governor, and the operation is off the extension of the engine shaft, between the crankcase and the reverse gear. For regulating the fuel pumps, such as shortening the stroke or cutting them out of operation, there is a hand wheel and lever control respectively. On the after cylinder there is a hand-operated adjustable air starting valve, pressure being maintained in a reservoir from the combustion in the cylinder to about 200 lb. per square inch.

On the starboard side of the engine, and mounted on the cylinders is a battery of plunger pumps for lubricating purposes. The little layshaft carrying the cams operating the plungers is actuated in turn by a ratchet drive from an eccentric on the after-end of the engine shaft; the same eccentric, by the way, also operates the bilge and water-circulation pumps. Each lubricating pump is equipped with a hand-adjusting screw, and connected to each screw is a small indicating hand to denote its position; by turning to the right the oil supply is varied in accordance with the demand of the particular working part that it feeds. On moving the screw in the opposite direction, the individual supply is entirely cut off. Thus even if the engine has been left idle for a number of hours, the engineer can at once see if the lubrication arrangements are in order.

The Cross

This motor, which is of the four-stroke type, runs at a higher revolution speed than any other oil engine of which we know, the speed being 650 r.p.m. The chief objection to such a high rate of speed is that with heavy commercial craft the best possible propeller efficiency cannot be obtained. On the other hand, great flexibility is available, the engine running under load down to 250 r.p.m., which is valuable for manœuvring. The Cross motor is made by the Aster Engineering Co., of Wembley, and by the Westinghouse Brake Co., of London.

On the up-stroke of the piston air is compressed in the hot bulb to 180 lb. per sq. in., and at 20 degrees, or $\frac{3}{8}$ in. from the top of the stroke, fuel is injected from the plunger pump, and the atomized fuel is combusted. About 30

HEAVY-OIL ENGINES

degrees from the bottom of the stroke the exhaust valve opens and closes again on the top of the upward stroke. Just on the finish of the exhaust stroke both the inlet and an auxiliary valve in the hot-bulb open, an addition to pure air being drawn into the combustion chamber, the bulb is well scavenged, keeping it free from all carbon deposits. For starting purposes, the exhaust valve cam-shaft is fitted with a half-compression device.

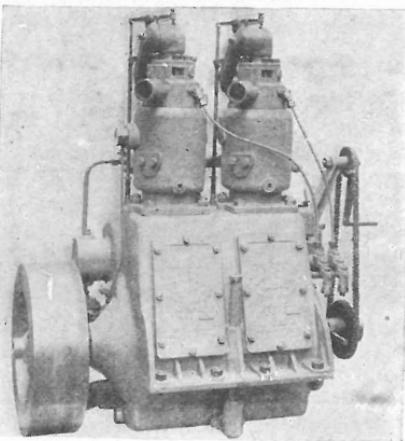
The fuel pump is actuated by a small cam striking a roller, which is mounted on a swinging bell-crank, the force being transmitted to the plunger of the pump. On the same cam-shaft is a governor gear, and the latter is connected to a small spring-controlled striker, which in the ordinary way swings clear of the bell-crank carrying the roller operating the fuel pump. As the weights of the governor expand through any excess engine speed, the small striker hits a step in the bell-crank and, in addition to lifting the roller clear of the operating cam, gives $\frac{1}{16}$ in. stroke to the fuel pump. So it will be seen that the fuel supply is never cut right out, but only diminished.

On the after-end of the cam-shaft is a bevel-driven vertical shaft, and to this shaft is connected rotary-type water circulation and lubrication pumps. The fuel consumption under load of the 10-12 h.p. single-cylinder model is 0.63 lb. per brake-horse-power per hour, with reductions in the higher powers.

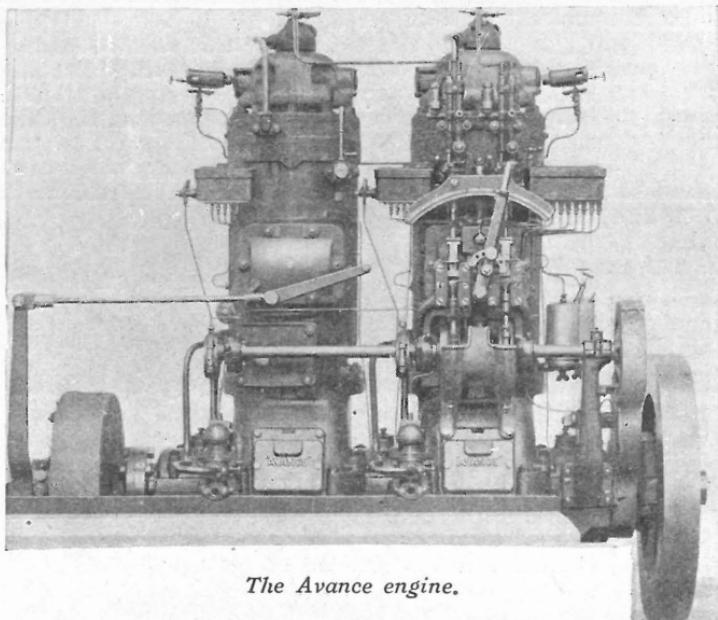
The Avance

Constructed in Sweden, the home of this type of marine engine, the Avance is made in a variety of models, the powers ranging from 3 h.p. to 400 h.p., and is intended for use in commercial vessels where continuous hard running with little skilled attention is required; heavy residual oils which are lighter than water, or else common paraffin, may be consumed as fuel.

The principal feature of the design is the arrangement by which water is injected into the cylinder with the oil fuel charge, and this is accomplished by connecting the oil fuel injection pump with a water pump, which forces a



The Aster and Westinghouse Cross engine.



The Avance engine.

supply of water approximately equal in volume to the fuel charge into the hot ignition bulb at the top of each compression stroke.

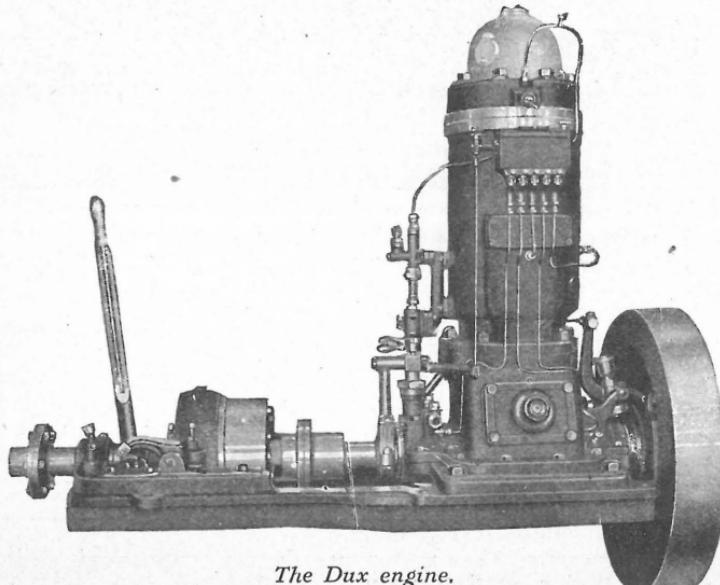
On reaching the hot-bulb the water is vaporized and, absorbing some of the heat generated by the burning of the fuel, expands as low pressure steam, thus contributing to the total pressure on the piston during each impulse stroke; the water evaporation also has the effect of keeping the cylinder cool, and aids the perfect combustion of the full charge. It also tends to keep the cylinder and piston head free from carbon deposit, even when thick oils are being used. But, as we mention elsewhere, it means that a considerable amount of fresh water must be carried if the vessel is to work on tidal rivers or the sea, and this occupies a certain amount of space that might be given over to cargo, so advantages also mean disadvantages.

The piston is air cooled, and the usual system of cooling the cylinders by water jackets is adopted. The 3 h.p. Avance engine is designed to run on paraffin only. As regards propeller control, Messrs. Boving and Co., the London agents, supply both reverse gears and reversible propellers for use with the smaller engines, and the larger engines are made directly reversible by pre-ignition up to 120 b.h.p. and by compressed air from that power up to 320 b.h.p. Regarding fuel consumption, the average, Messrs. Boving state, is 0.5 pint per b.h.p. hour, and lower in the larger sizes. The makers are Messrs. Hjorth, of Stockholm.

The Dux

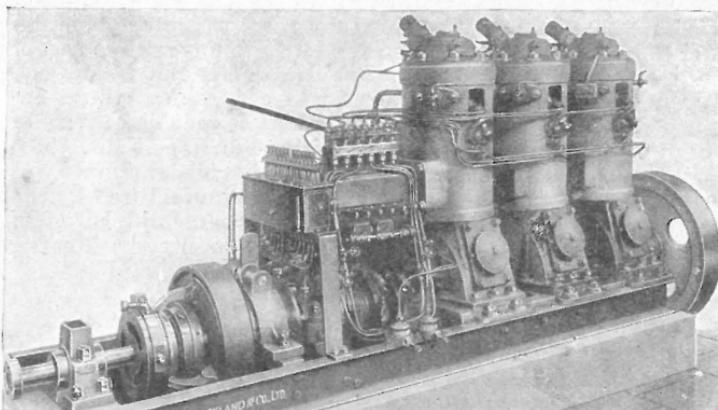
Intended chiefly for heavy commercial work, the Dux engine is strongly built. It is of the two-cycle, two-port, non-reversible pattern, and no water drip is used, the fuel used being paraffin or light residual oil. For starting, the ignition bulb is heated by a blowlamp in the usual manner, and when this is sufficiently hot a stroke is given to the oil pump by means of a hand lever, and the flywheel is then turned round against the compression, the resistance causing it to swing back sharply, and so the engine fires and runs in the ahead direction.

Fuel is injected in the hot bulb just before the end of the stroke, when the compression is partly completed, thus no fuel is lost through the exhaust port. The compression is about 130 lb. per sq. in. Only a water-circulating pump, and oil pump, and forced lubricating oil pressure pump are outside of the cylinders, there being no other exposed working parts except the governor gear, which controls the fuel charge by varying the stroke of the plunger type pump, and not by the hit-and-miss principle. The clutch is of the expanding pattern. Unless otherwise specified, these engines are set to run on paraffin, having a specific gravity of about 0.835 and a flash-point of about 96 degrees Fahr. The Dux is of Scandinavian design and construction, was originally known as the Primus, and is manufactured by the Ljunggrens Verkstads A.-B. of Kristianstad, Sweden. Lately it has been taken in hand in this country by Messrs. Thompson and Macgregor, of Liverpool.

*The Dux engine.*

The S.S. Standard

Here we have an engine of Dutch design, manufactured in this country under licence by Messrs. Simpson-Strickland, of Dartmouth, Devon, and it is of the two-port, two-stroke type, with gas oil as the principal fuel, although oil with a specific gravity of 0.900 can be used, the fuel consumption with gas oil being about 0.55 lb., or 0.50 pint per b.h.p. hour. It is made in models ranging from 15 h.p. to 120 h.p., the speeds being 450 r.p.m. and 280 r.p.m. respectively, the intermediate powers having varying speeds accordingly. Being of the two-stroke type, it is naturally to an extent reversible, but there are no devices fitted to perform this directly, a reverse gear being fitted instead. Starting is by compressed air above 20 h.p., but below this the flywheel is used as a lever to swing over the engine. The governor



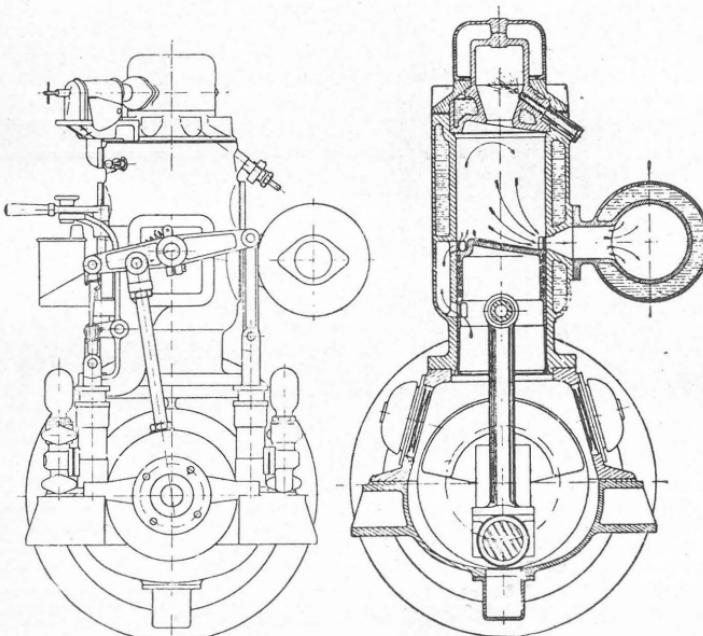
The Simpson-Strickland—Standard engine.

is of the centrifugal type, and as the weights are swung outward by the force caused by the engine speeds, these weights work to and fro by means of a lever device, a small tapered plate or wedge which is arranged between the striker and the plunger of the fuel pump. Consequently, the stroke of the pump is thus easily varied, and so diminishes or increases the fuel injection supply as the case may be. Lubrication is by force feed from a plunger-type pump driven off an eccentric placed between the reverse gear and the engine, and the oil supply is led to the working parts via a battery of adjustable sight feeds. From an accessibility point of view, the arrangement of the fuel pumps and the lubricating battery at the after-end of the engine is to be commended, as this facilitates the engineer's duties. The designers of this motor are Messrs. Steijaard and Jannette Walen, of Rotterdam.

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The Ailsa Craig

This is the most recent of hot-bulb marine engines to be placed on the market, and, at the time of writing, the first set of engines are passing through the workshops of the makers, the Ailsa Craig Motor Co., at Strand-on-the-Green, London, W. The present models are four in number—one, two, three, and four cylinders respectively, each 7 in. bore by 9 in. stroke, turning at 400 r.p.m. The smallest develops 10 h.p. and the largest 40 h.p. Arrangements are being made for larger powers, and these will be direct-reversible;



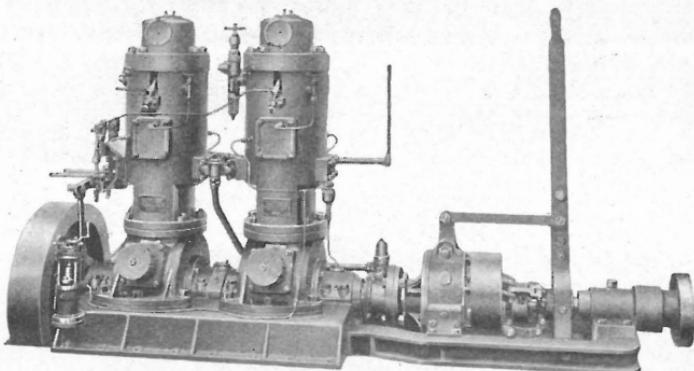
The Ailsa Craig engine.

and the 30 h.p. and 40 h.p. motors can be made reversible if desired, otherwise reversing is by a combined clutch and gear. The Ailsa Craig engine is of the two-stroke three-port type, and efforts have been made to reduce the working parts to a minimum. At the after-end an eccentric on the crankshaft works, by means of a vertical rod, a rocking lever swung on the cylinder wall. This rocker actuates the plunger-type bilge pump and circulating water pump, and the same mechanism provides a means of operation for the fuel pump. Governing is on the hit-and-miss principle, so that if the engine speed exceeds its normal revolutions, a stroke, or more, of the fuel pump is missed and so no power is developed until the proper speed is re-attained. Lubrication is by a force-feed lubricator, each working

part having its own adjustable sight-feed. Other parts of the engine are in accordance with modern practice.

The Tuxham

Accessibility may easily be claimed as a leading feature of the Tuxham, an engine manufactured in Denmark and sold in this country by Anders Willadsen, of Newcastle-on-Tyne. It will be seen that the overall length for the power is a little more than is usual, the reason for this being that the cylinders are arranged fairly wide apart, allowing the main bearings to be exposed for easy removal or inspection,



The Tuxham Engine.

and the same feature is applied to the end main bearings. They are all ring-oiled. This engine, of the two-stroke enclosed type with crankcase compression, is essentially a commercial engine, being of the heavy-duty class with a revolution speed of 300 per minute. Made in powers ranging from 3 b.h.p. to 300 b.h.p., the fuel that can be used is any paraffin or residual oils lighter than water. With the smaller sizes a reverse gear is employed, but for the large models the reversing is direct. Fuel is injected into the hot-bulb by means of a plunger pump, the governor controlling of which is arranged on the throttle system, in which the cylinder is not cut out periodically, as the stroke of the pump is directly regulated by the governor. The fuel consumption averages about 0.55 lb. per b.h.p. hour. Water injection is fitted, but can be dispensed with.

An outstanding feature is the offsetting of the cylinders, which enables a direct thrust to be given by the piston on the power stroke without side strains. Compression is about 180 lb. to 200 lb. per sq. in. Lubrication of the piston and gudgeon pins is by a Mollerup lubricator, while the water circulation is by a plunger-type pump. The makers are the Tuxham Maschinfabrik, of Copenhagen.

HEAVY-OIL ENGINES

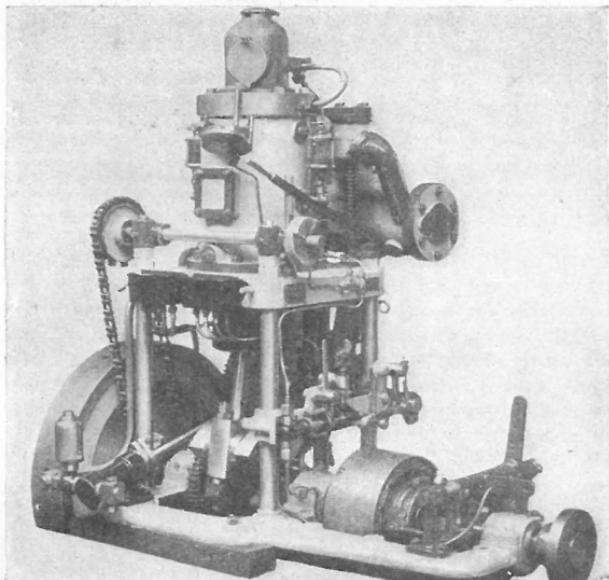
The Grampian

It is rather curious that in a country where the four-stroke petrol and paraffin marine motor predominates the two-stroke heavy oil engine should be the more largely adopted, despite the fact that the four-stroke type is thought to be slightly more economical in fuel consumption.

In the Grampian we have a Scottish-built four-stroke hot-bulb engine with radical departures from the majority of this class, the usual closed crankcase being replaced with an open crankpit with the cylinders each carried on four solid steel columns. The compression is rather low, being only 100 lb. per sq. in., and so the makers advise the use of paraffin fuel in preference to heavy oil.

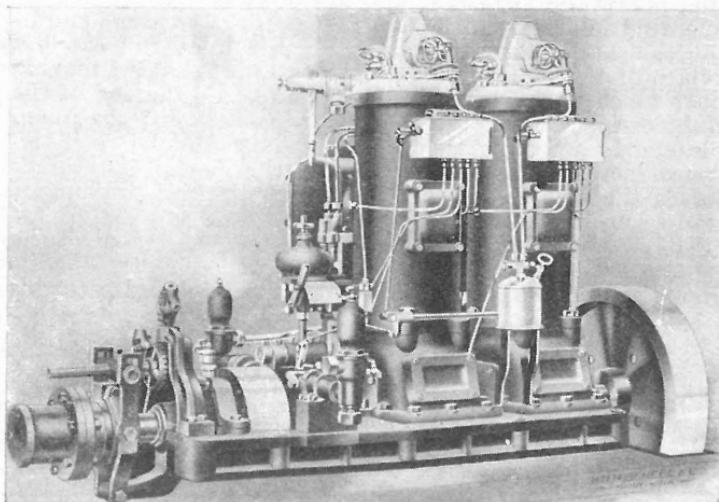
Between the two after columns is a bracket carrying the fuel pump and governor, and the plunger of the pump is operated indirectly off a cam fitted on the extreme end of the camshaft, the latter actuating the inlet and exhaust valves of the main cylinders. This cam strikes a moving link, which works on an inclined plane, and the end of the link carries a steel knife-edged striker that hits the pump plunger. Governing thus becomes quite simple, as if the speed increases beyond the normal the inertia of the link raises the striker, causing it to miss the pump plunger, and so no fuel is injected.

The actual injection occurs at the commencement of the suction stroke, and so is compressed with the atmospheric air. For starting, no compressed air is employed with this



The Grampian Engine.

model, but there is a free-wheel chain-starter mounted upon the cylinder base plate, and in addition to a half-compression set of cams, there is a lever which raises the valves on the compression stroke. For mechanically controlling the engine speed there is but a single hand wheel, which regulates the amount of fuel injected by shortening or lengthening, as the case may be, the stroke of the pump. Lubrication of the main bearings is by two siphon wick-fed lubricators mounted on the cylinder base-plate, there being four leads from each box, and lubrication of the cylinders is by two sight-feed drips. Water circulation is maintained by a plunger pump driven by an eccentric on the forward end of the camshaft. The speed of the single-cylinder 16 h.p. model is 400 revs. per minute. Higher powers are, we understand, slower running.



The Grei Engine.

The Grei

One of the features of the Grei hot-bulb engine, which is a Norwegian production marketed by Messrs. W. and S. Pollock and Co., of Glasgow, is that water drip is provided, but instead of injecting this into the hot-bulb or combustion chamber, it is led into the crank chamber, or into a duct leading from the crank chamber, and it is claimed that this has the result of reducing the amount of water required to a minimum, an important thing with cargo-carrying craft. The engine is of the two-stroke non-reversible class, and is of the three-port type.

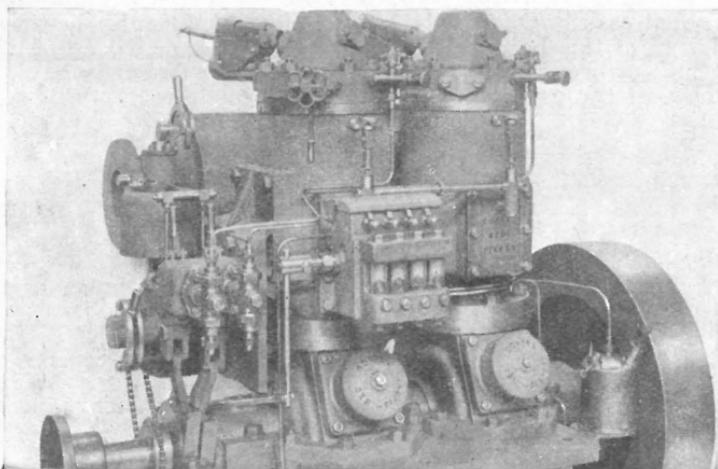
One of the main differentiations between the two-stroke types is that some are three-port, while others are of the two-port design. With the three-port class there is a port

HEAVY-OIL ENGINES

on one side of the piston, enabling the charge of air to be led into the combustion chamber through a passage in the cylinder wall. In addition to being lip-shaped, the Grei engine piston top is domed, to facilitate scavenging. An interesting point in connection with the governor controlling the plunger-type fuel pump is that it allows the stroke to be adjusted by hand while the engine is running, thus varying the amount of fuel injected, and, consequently, the engine speed. The Grei motor is built by Messrs. A. Gulowsen, A.S., of Christiania.

The Coates

Of British construction throughout, the Coates engine is of the two-stroke class, intended to consume light residue oils, gas-oil or paraffin. It is made by Messrs. J. Coates,



The Coates Engine.

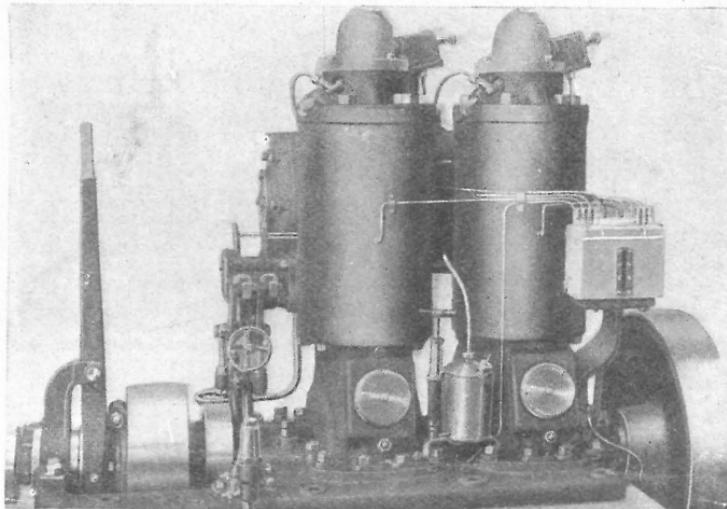
of Stockport, in sizes ranging from 8 h.p. to 80 h.p., and is of the non-reversible type, a separate reverse gear being supplied. It is a moderate-speed engine, the revolutions being from 300 to 450 per minute, according to the power developed. The smaller sizes are started by hand, but compressed air gear is fitted to the large motors. The principal feature of the design is the governing arrangements. Fuel is injected by means of a plunger pump, whose length of stroke varies with the position of the governor, through the medium of a tapered cam sliding axially on the shaft. Forced lubrication through sight-feed lubricators is adopted, and all parts of the mechanism of the engine are strongly made, so it should be well suited for the purpose intended, namely, that of heavy-duty commercial work.

With the new single-cylinder 40 b.h.p. at 340 r.p.m.

model there is fitted a Hartung governor, which is chain-driven off the crankshaft. This governor operates a sliding wedge arranged on the top of the pump eccentric rod, the wedge regulating the stroke of the fuel pump. When using gas oil of .87 specific gravity, an over-load of 20 per cent. was obtained on test for one hour, the fuel consumption being 0.57 pint per b.h.p. hour. Tarakan oil fuel was also used successfully, but with an increased consumption and a slight falling off of the power.

The Hexa

This is a Swedish production, and has been adopted in this country by Messrs. Sophus, Berendsen (London), Ltd. It is purely a heavy-duty commercial engine, and is of the ordinary single-acting two-stroke class with crank-case compression but without water injection, except in special cases. One of the chief points of difficulty in the design of this hot-bulb type of motor is the provision of a means of preventing the escape of fresh air from the crank chamber through the bearings.



The Hexa Engine.

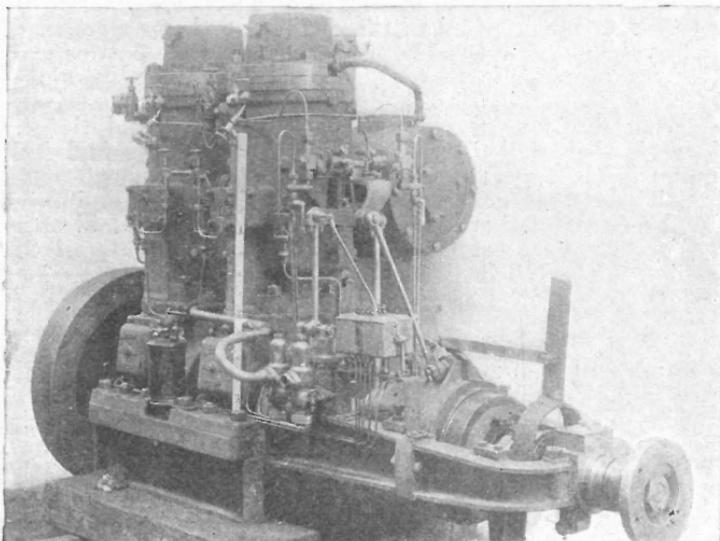
In the Hexa motor it is accomplished by means of special packing rings between the crankshaft and the crankcase, these rings forming a sort of labyrinth packing and being quite independent of the main bearing, which can be taken out and adjusted without altering the tightness of the crank chamber. For admission of air into the crank chamber during the suction stroke, valves are provided on the crank casing of a special patented type, these being made from steel plate and ground and hardened, and the valves form their own valve springs.

HEAVY-OIL ENGINES

Each cylinder is provided with a separate fuel oil pump, all the pumps being controlled naturally from the same governor. This governor for marine purposes is of the ordinary "hit-and-miss" type. Another important feature is that between the hot bulb and the cylinder proper there is a removable piece screwed into the cylinder head, and this is changed for another of different orifice when it is necessary to use other fuels. Thus it is possible to regulate the temperature of the bulb according to the fuels and conditions under which the engine has to work. For starting in the smaller sizes the flywheel is turned by hand, whilst in the larger sizes compressed air is employed. For this latter purpose a small air compressor is provided.

The Kromhout

The Kromhout hot-bulb engine is of the two-cycle type, the initial heat for starting purposes being obtained by means of blow lamps. These lamps are started up about 15 to 20 minutes before the engine is required. When the heads are sufficiently heated and the engine is started, the lamps are dispensed with, the ignition then being automatic. The fuel is injected into the cylinder by means of force-feed pumps, there being one pump per cylinder. All the fuel pumps are operated eccentrically from the crank-shaft, and are controlled by means of an automatic governor, which prevents the engine from racing if the propeller heaves out in a seaway, or when the control lever is put in the neutral position. The action of this governor, and thus the revolutions of the engine, can be varied at



The Kromhout Engine.

will by a quadrant fitted on deck close to the steersman. In common with many two-cycle engines the Kromhout engine uses fresh water drip to assist in cooling the ignition bulb, but a special feature is that this water is not, as usual, drawn into the cylinder with the rush of scavenging air from the crankcase, but is injected into the engine by means of a force-feed pump similar to the fuel injection pump, so that in the Kromhout engine the consumption of fresh water does not exceed that of fuel, instead of being twice as much.

The makers of the Kromhout engine have practically concluded exhaustive experimental work they have been carrying out for several months, with a view to eliminating the use of water injection entirely, without the starting blow lamps having to be lit up, when the engine is running on the governor, which is necessary with most existing types of hot-bulb engines not using water injection, and without increasing the quantity of fuel used per b.h.p. So far have they succeeded that they expect to place a new type of engine on the market shortly, and, in addition to having eliminated the use of water injection in this new design, have had the satisfaction of being able to also reduce the consumption of fuel per b.h.p. As regards the consumption of fuel, on the test bench this varies from 0.70 pint per b.h.p. per hour for the smaller engines down to 0.52 pint per b.h.p. for the largest. In England this motor is built by Messrs. Plenty, of Newbury, and in Holland by the Kromhout Motor Co., of Amsterdam, while it is marketed by Messrs. Perman and Co., of London.

The engine is started by means of compressed air, a bypass valve being fitted to the engine, so that a portion of the explosion is utilized to fill compressed air bottles, and this compression is used to give the first turning movement to the engine. The engine is barred up into the starting position by means of the flywheel, and the air lever is then pulled, and at the same time the fuel feed pump is also operated by hand, injecting a charge of oil which vaporizes on the previously heated bulb and fires. In the event of there being no compression available the engine can be started by hand. Another feature of the engine is the lubrication, the oil being fed to the various points by valveless pumps.

Other makes of hot-bulb marine heavy-oil engines include the Dan, Petter, Alpha, Gideon, Swiderski, Blackstone, Griffin, Drott, Loke, Original, Volund (Neptune), Fafnir, Sevena, Lavahn, Blanchard, Millot, Hein, Van Rennes, Triton, Stanley, Heaps, Fairbanks-Morse, Remington, the D.A.G., and the A.B.C., but, unfortunately, space prevents our dealing technically with these in this particular edition. The Dan, Alpha, Blackstone, and Griffin motors were fully described in the last edition, whilst most of the others have been dealt with in "The Motor Ship and Motor Boat."

CHAPTER XII

Paraffin-petrol Engines

Types of Motors Suitable for Small and Moderate-sized Commercial Craft

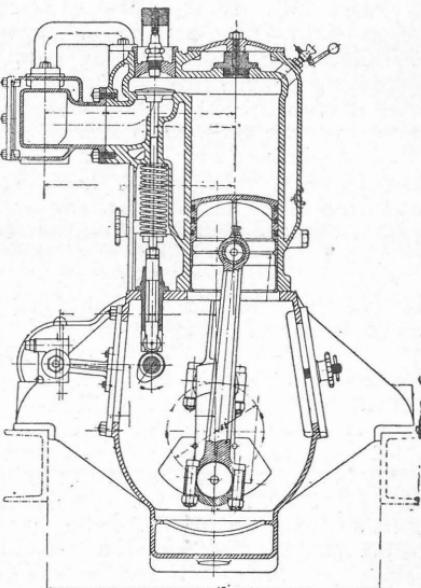
FOR certain classes of commercial boats the paraffin-petrol motor has been very popular in the past, and is likely to be used in even larger numbers in the future, especially as the tendency is to reduce the revolution speed, thus making it more suitable for heavy craft. By the term paraffin-petrol we mean an engine that has been designed to run on paraffin with arrangements for using petrol to facilitate starting. As is discussed in the vaporizer and carburetter section, it is necessary to heat paraffin before it can be vaporized, whereas petrol is easily vaporized by atomizing and mixing with the atmosphere. Therefore where there are no arrangements for starting on petrol, it is necessary to utilize the services of a blow-lamp in order to produce the necessary heat in the vaporizer. Some engines, it will be found, are in reality petrol motors furnished with a special exhaust or lamp-heated device, of which there are many on the market, and while this arrangement is often satisfactory, it will be found that this is not the most economical method, as when an engine is specially designed for petrol the greatest consumption economy, apart from the cost of fuel, is obtained with that spirit; so with a motor intended for the heavier oil, the consumption per b.h.p. hour will generally be found to be lower than with an adapted petrol engine.

For small and moderate powers the paraffin-petrol system is excellent, and it is chiefly in powers of 50 b.h.p. and upwards that the hot-bulb heavy-oil engine shows such material advantages in fuel economy. In certain cases, such as fire-floats and salvage vessels, auxiliaries, or any other class of craft requiring to start without any delay, this system is almost essential, as hot-bulb, or pure paraffin engines require from 12 to 20 minutes to heat the vaporizing chamber. In the instance of small fishing boats, paraffin-petrol engines enable the fishermen to proceed immediately after a shoal of fish independent of the wind and tide, and in this industry the last few years has seen the installation of nearly 2000 motors in the British Isles alone. In some boats, however, petrol has been the sole fuel; but this is the exception rather than

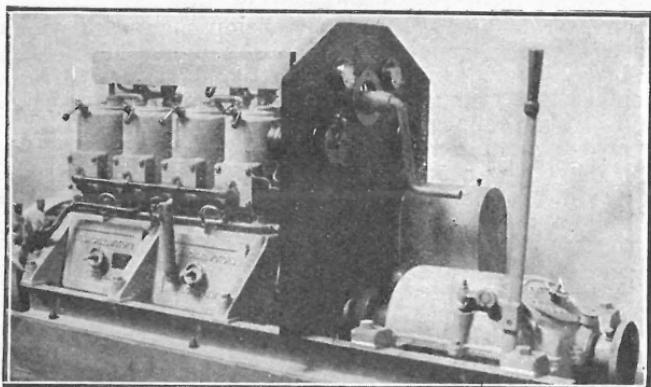
the rule. Lately there has been a tendency among manufacturers to reduce the engine speed, thus allowing a larger and more efficient propeller to be fitted and reducing the wear and tear of the working parts, but at the same time a slower engine is necessarily a heavier one, and so the weight per b.h.p. is greater. Of the paraffin-petrol motors there are many on the British market, but space is the factor which prevents us dealing with more than two dozen different makes, and of these the description is necessarily brief.

The Ailsa Craig

The outstanding feature of the Ailsa Craig marine motor is the adoption of the "off-set" principle for the cylinders, which enables the cranks to receive direct thrusts from the pistons on the down stroke without setting up side strains, and the makers, the Ailsa Craig Co., of Chiswick, W., find that the design has material advantages. Of the four-stroke medium-speed type the engine is provided with enclosed valve-tappets; in fact, the only exposed working part is the flywheel. The four-cylinder 35 b.h.p. model develops its power at 940 r.p.m., and the fuel consumption when using paraffin works out at 0.625 pint per b.h.p. hour. It can be run down to 275 r.p.m. under load, at which speed 9 b.h.p. is developed. The cylinders are of the L type, so that the valve - operation arrangements are all on the starboard side, where are also carried the vaporizer and the lubricating supply and ignition systems. The cylinders and exhaust branch are water-cooled, the pump, of the plunger type, being driven off an eccentric at the forward end between the flywheel and the crankcase. The carburetter and vaporizer are one, and not separate units, as with some paraffin-petrol motors, and there is no float-feed chamber, the fuel being fed by air pressure, or by gravity, to a multiple jet in the mixing chamber, and



Showing the "offset" design of the Ailsa Craig engine. The cylinder is not in line with the centre of the crankshaft.



The Ailsa Craig engine.

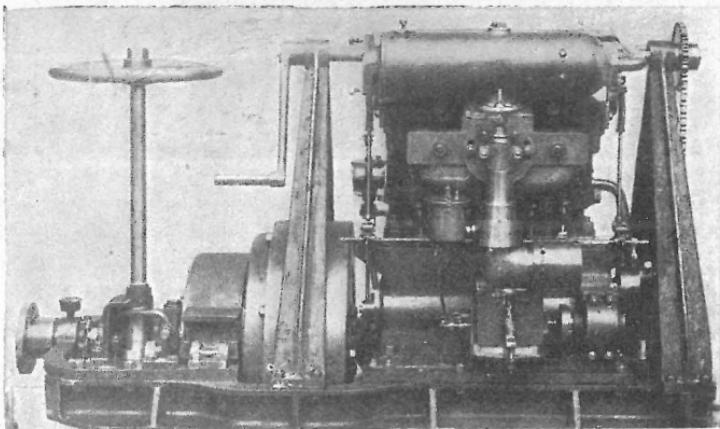
the supply is regulated by the suction of the piston. This vaporizer is exhaust heated, the hot gases passing partly around the mixing chamber and through a central passage.

When it is desired to run on petrol, there is a hand-controlled flap-valve, which shuts off all, or part of, the exhaust gases leading to the vaporizer, the gases then passing away directly through the main exhaust pipe. Arrangements are provided for starting on paraffin with the aid of a blow-lamp, and this will be found necessary on board craft where it is inadvisable to carry even a small quantity of petrol. A fuel filter is provided between the jet and the tank, and the jet is controlled by a milled head on the needle valve. Lubrication is by an eccentric pump driven off one end of the high-tension magneto driving shaft, and all working parts receive the oil under pressure. Various other powers are made.

The Barcar

Being of the moderate-speed type, namely, 750 revolutions per minute, the Barcar engine is sometimes used in conjunction with a reduction gear; but this is only necessary where such craft as barges, tugs and lighters are concerned, and the speed is low enough to allow of direct drive in the case of fishing boats, passenger launches, etc. It is made by the Phoenix Motor Co., of Altrincham, and the fuel consumption of the 15 h.p. set is 0.7 pint per b.h.p. hour. There is a separate vaporizer to each cylinder, but the paraffin first passes through a special carburetter, which has the choke-tube, throttle and extra air controlled by a small hand wheel. Swedish lamps or petrol is used for starting, and the lamps are removed as soon as the engine is hot, the exhaust gases keeping the vaporizers to the desired temperature. To an independent throttle a centrifugal governor is connected, the latter being

actuated off the forward end of the camshaft. Under the carburetter is arranged a low-tension magneto, which is driven at engine speed, the ignition being of the make-and-break type. Lubrication is by sight-feed drip and by splash, the crankcase being divided by a web to insure the forward connecting rods picking up the oil. All valves are arranged on the starboard side, the camshaft being driven by a two-to-one gearing at the forward end. Each cylinder has a removable cover for cleaning out the



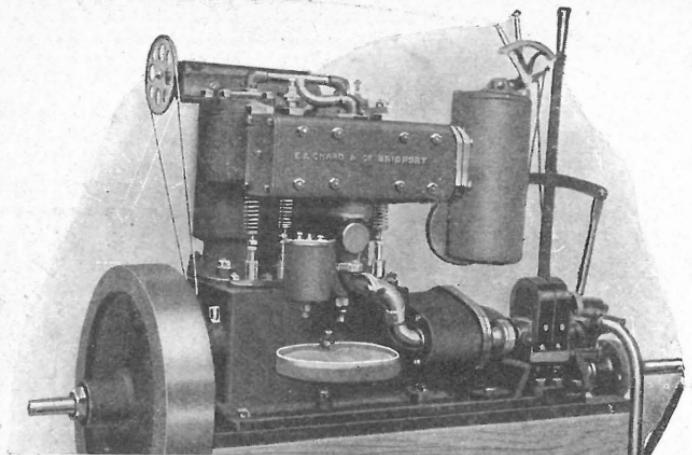
The Barcar engine.

water jacket, and this cover is held down by a central nut screwed to a boss projecting from the head of the cylinder. The water pump, magneto and governor drives are at the forward end of the engine.

The Brit

These engines are designed to develop their full power at only 650 revolutions per minute. The cylinders are cast in pairs with all valves on one side, the single camshaft serving also to drive the water and oil pumps. Oil is lifted from a sump in the crankcase to a gallery of sight feeds on the starboard side of the engine, whence it is led to the bearings and working parts. Sight-feed drip is used with small sizes. The reverse gear is of substantial construction and of the "epicyclic" type, the operating lever giving "ahead," "neutral," and "astern."

The vaporizer has an automatic air valve which admits only a small quantity of air, and the mixture, after passing the mechanically-operated inlet valve into the combustion chamber, is reduced to the proper proportions by air admitted through a snifter valve in the cylinder head. In one model the bottom part of the crankcase, side bearers and thrust-block bearing form a single casting,

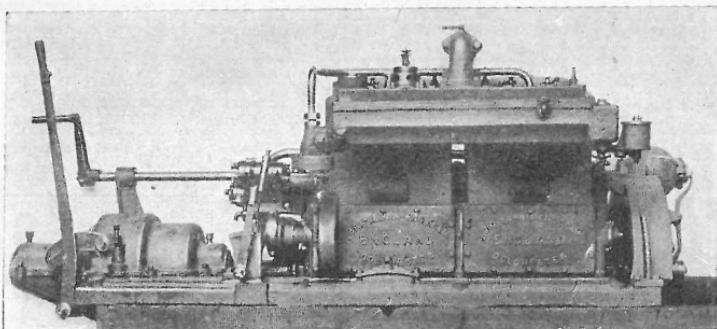


The Brit engine.

and lubrication is by a belt-driven mechanical lubricator. The larger models, which run only at 350 revolutions per minute, except for the largest size, the snifter valves in the head and the singly-cast cylinders, follow the design of the faster running models. To start up, the flywheel is turned round to a marked position, which brings No. 1 piston to the top of its working stroke and No. 2 piston just entering on its compression stroke. A charge of petrol vapour is then pumped into both cylinders by means of a hand-pump, and No. 1 charge is then ignited by tripping over the magneto, thus setting the engine under way. Governing is by the hit-and-miss principle on the vapour-inlet valve, so that when the speed increases above the normal air only is taken into and exhausted from the cylinder by way of the air-valve in the cylinder head. The makers are Messrs. Chard, of Bridport.

The Britannia

The Britannia engine is of the four-stroke type, and is of a fairly high-speed class, turning from 600 r.p.m. up to 1030 r.p.m., according to the size and power. The stock models and designs range from $7\frac{1}{2}$ b.h.p. to 300 b.h.p., although we believe that the largest size has not yet actually been constructed. They are non-reversible, so an epicyclic reverse gear and clutch are employed, and starting is by hand in the smaller sizes, with compressed-air arrangements for the larger sets. For the purpose of obtaining the initial heat for the vaporizer, a blow-lamp or petrol may be used, the vaporizer itself being of a simple type. The enclosed form of crankcase is adopted, the lubrication system being by force throughout the engine from a small pump, and a gauge is provided to



The Britannia engine.

check the pressure. With the recent designs ring oiled bearings are fitted for the crankshaft. Of late considerable improvements have been made, including enclosed valve tappets, etc., which tend to quiet running of the working parts. Ignition is by magneto, and a dual system is fitted in cases where desired. The engine is built by the Britannia Engineering Co., of Colchester, who also market them.

The Buffalo

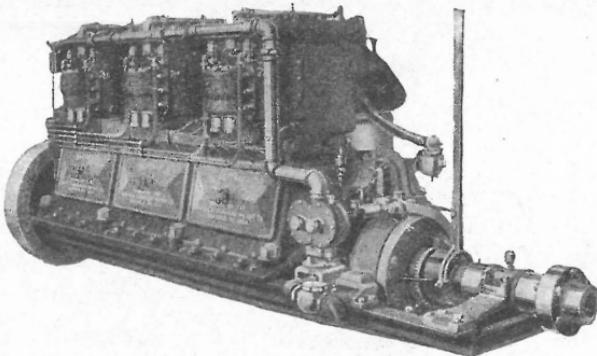
This engine should not be confused with the British-Buffalo, which is of a faster speed type. The Buffalo is made in the United States and handled in this country by Buffalo Marine Motors, of Waterloo Road, London, S.E. Altogether there are 19 different models in three series—high speed, medium speed and slow speed, 65 h.p. to 100 h.p., 3 h.p. to 100 h.p., and 10 h.p. to 150 h.p. respectively; but we can only deal here with the 150 h.p. commercial craft motor, and only engines in the same series run on paraffin. This particular motor has six cylinders, 10 in. bore by 12 in. stroke and turns at 300 r.p.m. It is of the non-reversing four-stroke type, and an important feature of the design is the arrangement of auxiliary exhaust ports, which are opened when each piston reaches the bottom of its stroke. Immediately outside the port in the cylinder wall is an automatic non-return check valve, which is also controlled by means of a dashpot. Thus any back rush of the exhausts at the end of the suction stroke is avoided. The exhaust manifold from the auxiliary ports is a passage cored in the cylinder castings leading between the two cylinders of each casting to the main exhaust manifold. To each cylinder is fitted a sight-feed adjustable water-drip for preventing too early combustion, cooling the cylinders and pistons, and increasing the power.

On the starboard side of the engine are arranged three vaporizers, one for each pair of cylinders. These are

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cylindrical-shaped castings containing a nest of thin copper tubes expanded into headers, and through the tubes the exhaust gases pass, well heating the chamber into which the fuel is drawn by the suction of the piston. On each side, and at the top of the castings, are carried the exhaust pipes, while at the lower end is a large exhaust manifold. Starting is by petrol until the vaporizers are sufficiently heated to take the paraffin. There are three float feeds for supplying the fuel. The fuel consumption of petrol is 1-10th of a gallon, or 0.7 lb. per b.h.p. per hour, and slightly higher when running on paraffin.

Air starting is provided, the air being passed to the admission valves in the cylinders from a rotary cylinder type distributing valve driven by bevel gears off the extreme forward end of the camshaft. Lubrication is carried out by means of a multiple mechanical feeder mounted on



The American Buffalo engine.

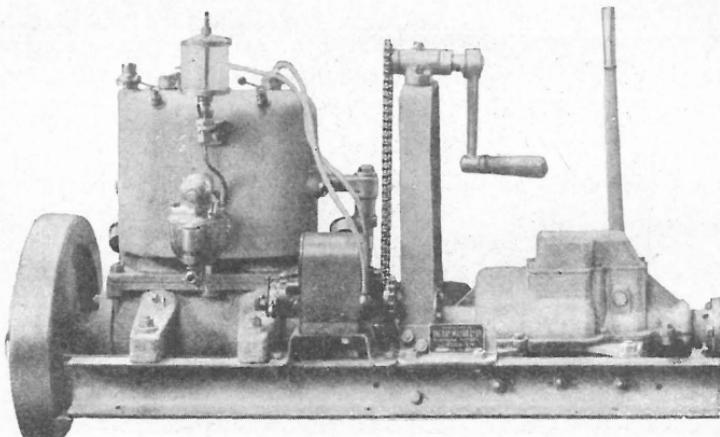
the forward cylinder. It consists of a force-feed tank, from which are led 29 sight-feed tubes to the main bearings, cylinder walls, etc. There are two pumps for maintaining the oil supply, one for raising the oil from the reservoir and through the sight glass, while the second accepts it and forces it to the working parts. Water cooling of the cylinders is by a rotary pump situated at the after-end of the engine, while ignition is by high-tension spark, a Bosch magneto and the Delco distributor system is employed, there being two plugs to each cylinder. The reverse gear is of the epicyclic type, with the expanding clutch.

The Day

It is not generally known that the Day was the first two-stroke marine motor to be constructed, and it is of the three-port principle, which design now is practically universally adopted for small two-stroke marine sets. The method of operation is quite simple. On the up-stroke (compression) of the piston, fuel, air and lubricating oil

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are drawn into the crank chamber by the suction created by the vacuum so caused from the carburettor through a port, and on the downward stroke (explosion) this mixture is compressed to about 3 lb. per sq. in. At the bottom of the stroke the mixture enters the combustion chamber via a passage and a port in the cylinder wall. On the up stroke it is recompressed in the combustion chamber by the piston and then fired in the usual manner by the sparking plug, this cycle of operations then being repeated. At the after-end of the engine is the pump, and this is chain driven off the shaft. High-tension magneto ignition is employed, and the normal position of the distributor is on the forward end of the crankshaft between the flywheel and the crankcase. In view of the absence of valves and camshafts, the whole design is very simple, consequently a clean-looking engine is obtained. The running



The Day engine,

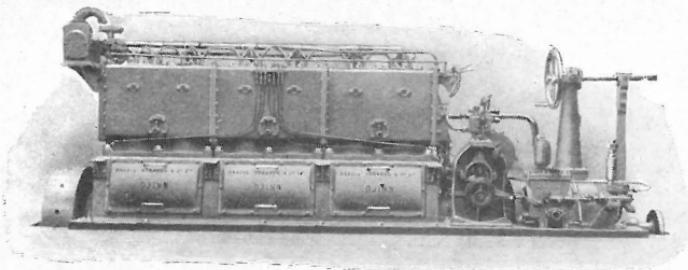
speed is higher than most two-stroke motors ; for instance, the four-cylinder $4\frac{3}{4}$ in. bore by $4\frac{3}{4}$ in. stroke develops 30 b.h.p. at 800 r.p.m. Where a free clutch is fitted, it is possible to reverse these engines by advancing the magneto. It is made by the Day Motor Co., London, S.W.

The Djinn

The Djinn paraffin engines are made in several types suited to varying classes of work. These may be roughly divided into two, viz., the slow-speed heavy type ranging from 5 h.p. at 500 r.p.m. to 130 h.p. at 325 r.p.m., and the moderate speed type, which includes engines of from $7\frac{1}{2}$ h.p. at 800 r.p.m. to 250 h.p. at 450 r.p.m. Perhaps the most distinctive feature of the Djinn engine is the vaporizing arrangement. Each pair of cylinders has its own special vaporizer and fuel jet, the supply of heat to the vaporizing

PARAFFIN-PETROL ENGINES

tubes being automatically regulated. Control is by hand throttle, a centrifugal governor operating on the "hit-and-miss" principle, preventing racing with a free engine or other conditions. Another feature of the Djinn engine is the accessibility of all parts. On the crankcase large doors are provided on one side for the inspection and adjustment of the bearings, these doors being sufficiently large to enable the connecting rod and piston to be withdrawn without knocking out the gudgeon pin. On the valve side of the crankcase, there is a single long door through which the camshaft and timing wheels can be easily taken out. A massive iron casting is used for the bedplate carrying the main bearings on cross-guides of box-section. The crankcase is simply a strong but light casting serving as an oil-tight case, as it does not carry the cylinders, these being mounted instead on mild-steel columns bolted through the bedplate. The cylinders have very large water-jacketed spaces and open flanged ends machined to receive the jacket doors.



The Djinn engine.

Each cylinder jacket is continuous and common to the others, the distribution of the cooling water being maintained uniform by a special pipe. The camshaft works in an enclosed oil-tight case; its bearings are split and adjustable, being supported on pedestal brackets secured to the bedplate and to the cylinder columns. Forced lubrication is fitted throughout, only the pistons being lubricated by sight-drip feeds. An adjustable pressure-regulating valve is fitted to the oil pump to prevent excess pressure in the delivery pipes, and an oil tray cast solid with the bedplate is carried right fore and aft on each side of the engine. Each size is fitted with forced lubrication and cooling water circulating pumps, these being of bronze throughout and of the plunger type. Engines above 20 b.h.p. are fitted with a plunger type of bilge pump and a water-cooled exhaust branch is fitted on each side. A strong chain-starting gear is fitted to all sizes up to 45 b.h.p. in the moderate speed type, and up to 23 b.h.p. in the slow speed heavy-duty type.

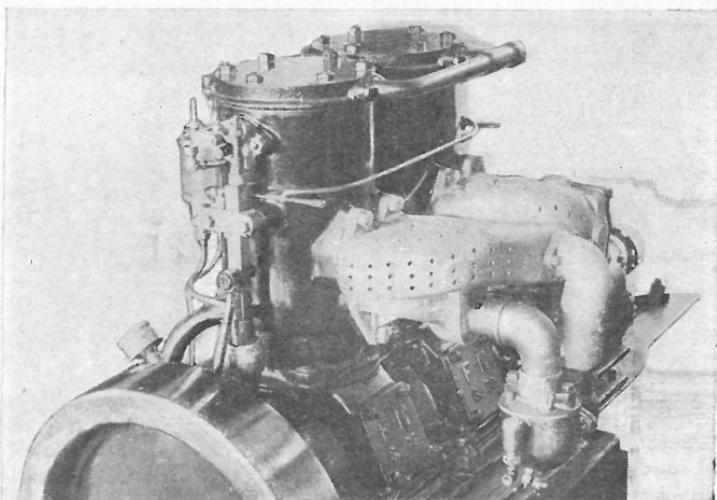
Above these respective powers, compressed-air starting is fitted to all sizes. The compressors for air-starting and blowing the syren are driven by the main engine, and

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hand gear is fitted as a stand-by. Messrs. Brazil, Straker and Co., of Bristol, are the makers.

The Fairbanks-Morse

The Fairbanks-Morse Co., of Southwark Street, London, S.E., manufacture three distinct types of commercial marine motors, namely, a two-stroke, a four-stroke paraffin-petrol set, and a hot-bulb heavy-oil engine. Of the last-named only a few have yet been built, this being a new model, and at the time of going to press details are not available. The two-stroke paraffin-petrol motor is of the heavy-duty type, turning at 550 r.p.m., and the makers find that the most suitable fuel is Russian vaporizing oil, generally known as R.V.O. It is of the three-port type, but differs from most designs in that there is no port in the piston, the third port being exposed when the piston is at the top of the stroke. This port is for the admission of fuel into the crankcase. After



The Fairbanks-Morse two-stroke model.

compression in the crankcase, the mixture passes through a channel in the cylinder wall and through a port exposed by the piston at the bottom of the stroke; at the same time a port on the opposite side of the cylinder is also exposed, and through this orifice the exhaust gases make their escape. As the piston comes up the mixture is recompressed and then fired.

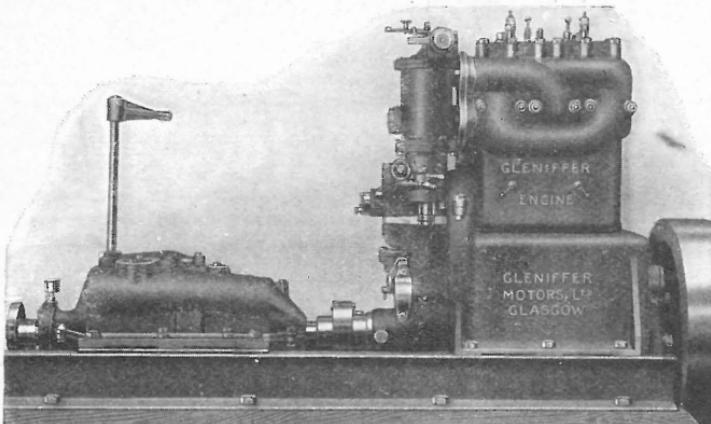
Around the exhaust manifold is an air jacket pierced with a number of small holes, through which the atmosphere is drawn, and from this jacket the Schebler carburetter obtains its air, which, being heated, vaporizes the paraffin spray. This hot mixture is then drawn into the crank chamber, where it is compressed by the down stroke of the piston. It

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is then forced to the combustion chamber as mentioned. Low-tension magneto ignition is fitted, and the make-and-break device is operated by the end of the rod that actuates the plunger-type water-circulating pump, there being one pump to each cylinder. The drive is, of course, by an eccentric on the crankshaft in each case. Lubrication is by sight-feed drip and by splash, with grease boxes to the main bearings.

The Gleniffer

For some considerable time Messrs. Gleniffer Motors, Ltd., have manufactured four-stroke type marine motors of various sizes, and now have added a commercial paraffin-petrol engine of 18-20 h.p. of improved design to their series. This engine is of the enclosed non-reversible type, there are two cylinders, $5\frac{1}{2}$ in. bore by 7 in. stroke, and the running speed is 600 to 700 r.p.m., so it may be classed among fairly-moderate-speed engines. With Gleniffer engines the well-known Westmacott vaporizer is fitted, and this, having been on the market for so many years, need hardly be described here. We believe that it was first introduced 10 years ago, and it is still largely adopted for marine work. As the valves of this engine are all arranged on the starboard side, the port view of the engine, as shown, is so free from accessory gear that it gives the impression that it is of the two-stroke class. The vaporizer, it will be noticed, is mounted on the after-end of No. 2 cylinder, and receives its heat direct from the exhaust pipe. There is also a small door for starting by blow-lamp, and for ease of starting a half-compression gear is fitted. Lubrication is automatic



The Gleniffer Engine.

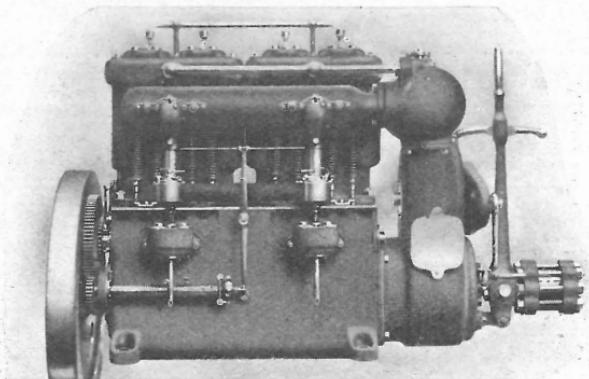
in action, and commences when the engine is started. A collector wheel revolves with the crankshaft, and carries oil from a sump in the crank chamber and delivers it into troughs below the crank webs. Dippers are fitted to the connecting-rod ends, which splash the oil to all working

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surfaces. Oil channels and cups are provided where necessary to catch the oil. The troughs are so arranged that the engine may be set at almost any angle or list without affecting the even lubrication. Enough oil is carried in the sump for a full day's run.

The Kelvin

A notable feature of the vaporization system of the Kelvin heavy-type engine is that provision is made for rendering each pair of cylinders independent, and this feature is pursued still further in the duplication of water pump and piping and of fuel tanks and piping, so that a four-cylinder engine possesses some of the advantages of twin engines. That is to say, that the chances of a breakdown occurring are rendered much more remote by dividing the engine into practically two units, which have only the main shaft in common. Compactness has been closely studied and achieved in the design. The crankcase is of square section, with a large inspection door to each pair of crank-throws, and a smaller hand hole, fastened by a thumbscrew, fitted to each door, for greater convenience. One side of the engine is entirely clear, except for the magneto, all the valves, exhaust branch, and induction piping being on the other side. The vaporizer to each pair of cylinders is a simple exhaust-heated box, with a throttle. Lamp-heating can be supplied. Lubrication is effected by splash, but provision is made in the crankcase for the splash to operate satisfactorily, even when the engine is raked at an angle of one in seven, this arrangement being the subject of a patent. Plunger water



The Kelvin Engine.

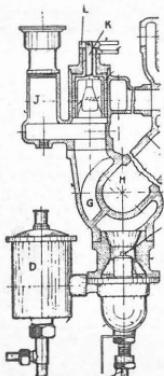
pumps are employed, the water from which, after passing round the cylinders, is discharged into the exhaust box, which is fitted transversely across the engine at the after-end. The throttles, one to each pair of cylinders, are regulated by a governor, driven off the half-time gearing, which is placed outside the crankcase, but protected

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by the flywheel at the forward end of the engine. A simple device is attached to the magneto to provide a strong spark when the starting handle is pulled over and thus to facilitate starting. The reverse gear is self contained with the engine, and all the control levers are mounted on the engine, the whole thus forming a compact set, which can easily be installed, the more so that the piping which is sent out to make the connections to the hull is of soft copper, which can easily be bent by hand, special couplings, to obviate screwing, brazing, or soldering, being supplied for the shaft as well as for the piping. The makers are the Bergius Launch and Engine Co., of Glasgow.

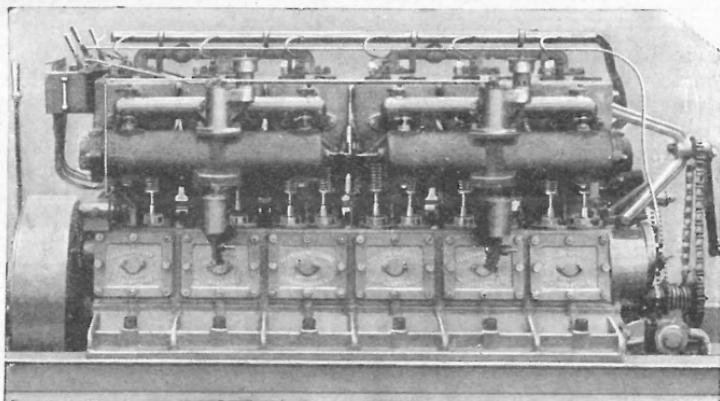
The Parsons

For many years the Parsons motor was of the concentric-valve type, in which the exhaust valve was contained in the inlet valve, and the mixture, after passing through a simple vaporizer, entered the inlet valve and was impinged against the hot exhaust valve top and vaporized. While the Parsons Motor Co., of Southampton, still construct this design of engine, their newest models conform more to modern four-stroke practice, as recent improvements to the vaporizer enable a heavy paraffin to be used with the ordinary plain duo-mushroom-valve motor. The new type is made in sizes from 7 b.h.p. to 90 b.h.p., in one to six cylinders, the speeds varying from 800 r.p.m. to 550 r.p.m., and all are built to Lloyd's and the Board of Trade requirements. The cylinders have the valves arranged on one side, and are operated by plungers and tappets off a single camshaft. For lubrication the crank-case is specially made with oil channels that collect the oil thrown up from the sump by the big-ends, thence passing by gravity feed through holes directly on to the main bearings. In addition there are oil feed cups to each bearing. When forced lubrication is fitted the after-end of the camshaft drives a plunger pump of the non-suction-valve type, which gives the necessary pressure.



Parsons
vaporizer.

Regarding the vaporizing arrangements, these can be followed from the drawing. The float-feed chamber (D) is provided with a three-way cock for the two fuels, and from the jet (E), which is provided with an adjustable needle (F), the fuel is drawn into the chamber (C), this being heated by the exhaust gases at H. At the same time air is drawn in at J, and the mixture passes into the combustion chamber through the sleeve throttle (K). Working inside this throttle is another throttle (L), which is connected directly to a centrifugal governor working on a vertical shaft driven off the forward end of the camshaft. Ignition is by a chain-driven magneto, and the latter is fitted with



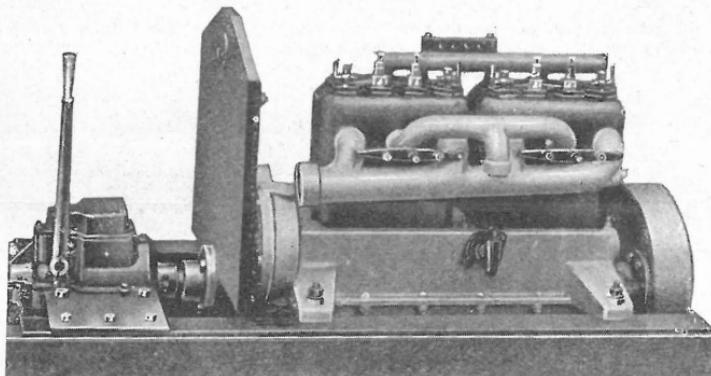
The Parsons Engine.

a special advance and retard arrangement by means of which an adjustment of about 30 degrees can be obtained. At one end of the magneto spindle a sleeve with a curved diagonal slot is fitted. To this is attached a collar operated by a control-rod mounted on a bearing, and by giving the latter the timing from full early to quite late it can be varied with a fixed point on the contact maker.

The Palladium and Wortham-Blake

Here we have an engine of American design handled in England by Palladium Autocars, Ltd., of London, it being better known in the States as the Kermath. In a slightly different form the same engine is marketed by Messrs. Wortham, Blake and Co., of Waltham Cross. It is made in a single model, and is of the four-stroke class, there being four cylinders, $3\frac{1}{2}$ in. bore by 4 in. stroke, developing 14 b.h.p. at 1000 revs. per minute. The cylinders are mounted on a cast-iron crankcase of the enclosed type, constructed in two sections. All valves are arranged on the starboard side of the cylinders, and are side by side, being operated by cams and plunger tappets in the usual manner off a camshaft. The latter is driven by two-to-one gearing at the after-end, and is enclosed by the upper section of the crankcase, while the valve tappets and guides are also entirely enclosed, there being one cover for each pair of cylinders. On the same side of the engine are mounted the carburetter, induction pipe and exhaust branch, the latter being held in position by a pair of long dogs. Just below the carburetter is mounted a small plunger pump operated by a cam for drawing the lubricating oil from the crankcase sump. From the pump the oil passes along a pipe to a sight-gauge fixed on the port side of the forward cylinder, thence it is forced, via the end main bearing, to the forward end of the crank-shaft, which is drilled hollow. In this manner the oil is

fed to all the main bearings and big-ends. Lubrication of the cylinder walls, pistons and gudgeon pins is by splash from the crank chamber. The high-tension magneto and water pump are operated by a cardan shaft on the port side of the engine. With this particular engine a special vaporizing device has to be fitted where it is desired to use paraffin, so it is more of a petrol-paraffin motor, rather than a paraffin-petrol engine, especially as the speed is somewhat higher than is usually to be met with in paraffin engines.

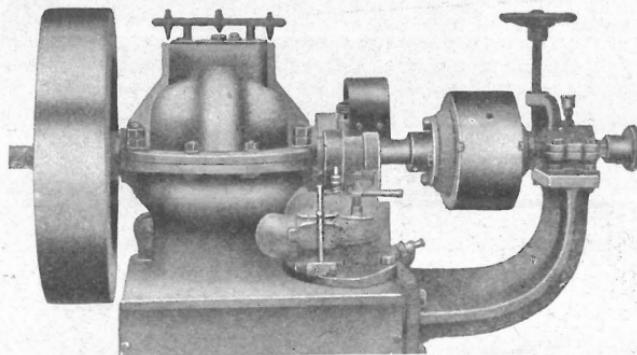


The Kermath (Palladium and Wortham-Blake) engine.

The Seal

The unusual position of the cylinder in the Seal engine renders this type peculiarly suitable for installations where economy of space is very important. The design may be described as inverted, the crankcase being above and the cylinder below. The great advantage of this arrangement is that the engine occupies little space above the floor, and another advantage is that no water pump is necessary, the circulation round the jackets being effected by the natural flow of water. The combustion chamber water jacket and port to the cylinder head are all contained in one base casting without any joint. The balanced crankshaft runs in phosphor-bronze bearings above the combustion chamber, and is enclosed in the dome-shaped crank cover that carries the lubricators for the bearings, crankpin, etc. The crank dome cover can be removed with half the bearings for the inspection of the piston and connecting rod, without dismantling any other part of the engine. The whole of the valve gear, oil feed, and ignition gear can be removed independently of the cylinder. Owing to the cylinder head being below the water-line, when installed in a boat, and to the natural tendency of warm water to rise above the cold, the water circulation is automatic. A valuable feature of the design of the connecting rod is

the provision for adjustment, both at the gudgeon-pin and crankpin end, by means of a strap. Lubrication provides no difficulty whatever, being effected by the drip from the oil channel above the engine at each down stroke of the piston, oil being splashed on each end of the connecting rod and the bulk falling into the trunk of the piston, where it is gradually used. The fuel, after admission through a suction-disc valve of special design, passes through a simple vaporizer to a chamber, where it awaits the opening of the automatic inlet valve. Once the oil feed is set by the regu-



The Seal engine.

lator it requires no more attention. The control is effected by means of a simple butterfly throttle. Magneto, coil, hot-tube, and automatic ignition can be fitted, singly, or as main and auxiliary systems according to the destination and requirements of the engine. If petrol is used for starting the engine, electric ignition avoids any delay for heating the tube. When, however, paraffin only is employed, the hot tube may just as well be used. In either case, after the engine has been running about five minutes, the automatic timed ignition takes up the firing, this being worked by a bulb, which, screwed to the combustion chamber, becomes red hot and ignites the mixture at the correct moment by the mechanical plunger which admits fresh mixture to the bulb. It is of the four-stroke type, and runs at moderate revolutions. The Seal Motor Co., of Hammersmith, W., are the makers.

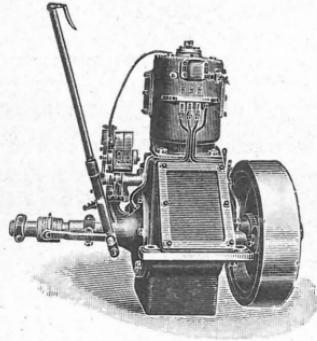
The Smart and Brown and the King

This marine engine, built by Messrs. Smart and Brown, is an extremely simple and substantial type, designed specially for small fishing boats and commercial work generally. It is a single-cylinder motor, 6 in. bore by 8 in. stroke, and is rated at 8 h.p., running at only 400 r.p.m. Every fitting that can possibly be dispensed with has been eliminated, and there is probably no simpler four-stroke engine in

existence. The crankcase is cast in one piece, with an end door at the after end, through which the crankshaft can be removed. There are very large panels on either side of the case, through which the valve tappets and also the big-end bearing can easily be reached. The cylinder has the valves side by side, and the combustion head is bolted on separately. A noteworthy point is the size of the main bearings. The crankshaft diameter is $2\frac{1}{2}$ ins., and the length of each bearing no less than $7\frac{1}{2}$ ins. The

engine will run on the commonest grades of paraffin, and the Lodge high-tension electric ignition is employed. This system has not been described in the ignition section of the "Handbook," so a brief reference may be made to it here.

A spark is provided by an accumulator and induction coil in the ordinary way, but the spark from the coil, instead of going direct to the plug, sparks across a separate gap and charges the inner coats of two condensers or Leyden jars. The



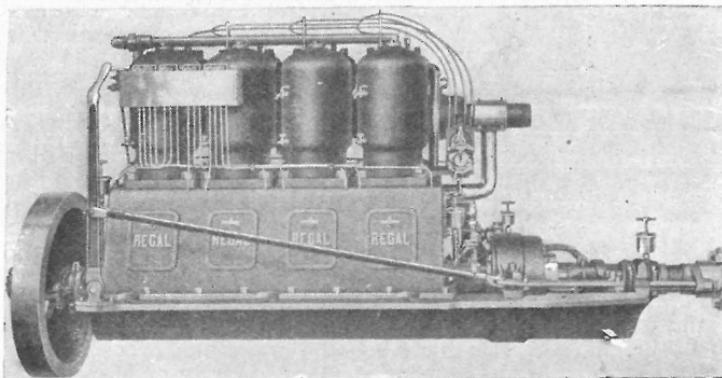
spark from the outer coatings of these jars is utilized to fire the charge. It cannot here be explained precisely why these effects should be produced, but it may be stated that what is called a high-frequency spark is supplied to the plug, which differs from an ordinary spark in that it is not so easily affected by wet or by a deposit of carbon. It may be noted that these engines are often fitted with reversing propeller gear operated by a lever and quadrant attached to the after main bearing.

In addition to the engine just described, Messrs. Smart and Brown manufacture other types of motor, among which must be mentioned a three-cylinder engine having the three cylinders cast en bloc. The engine generally is very similar to the single-cylinder heavy type engine, but magneto ignition is fitted as standard, with coil and accumulator as an auxiliary. Engines of similar design are made by this firm for Messrs. J. King and Co., of Limehouse.

The Regal

This is a four-stroke engine of American make, marketed by Messrs. Murphy and Steadman, of London, E.C., and the direction of rotation is clockwise, which should be remembered when ordering the propeller, otherwise the boat will run astern with the reverse gear in the ahead position and vice versa. Altogether 16 different sets are constructed by the makers, of which one series is of the heavy-duty type intended for commercial craft, and these are fitted with paraffin-petrol vaporizing devices. High-

tension Bosch dual magneto ignition is adopted. While using the same distributor and spark plugs there are otherwise two entirely independent systems of ignition; one by battery and one by magneto. This not only affords an independent emergency ignition, but by using the battery the engine may be started at a low cranking speed, and often upon the spark without cranking, by pressing a button on the coil, which cuts a vibrator into the circuit. The magneto is mounted upon a bracket on the left side of the engine to the rear pump. Water-cooling of the cylinders is by a plunger pump driven from an eccentric.



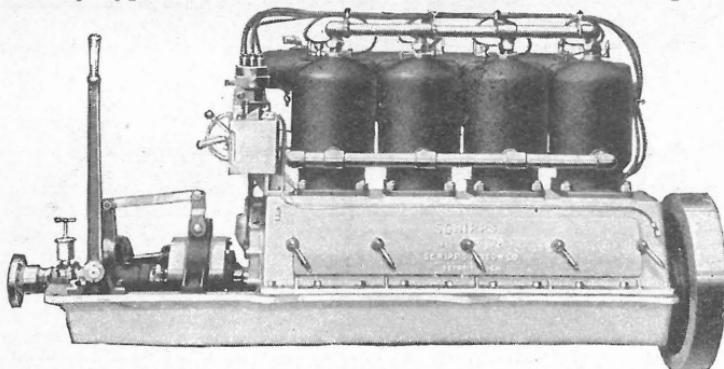
The Regal engine.

Directly at the back of the cooling water pump is a small gear lubricating pump, which draws the oil from a reservoir in the bottom of the crankcase base and forces it through a sight-feed to a distributor, which has a number of leads. Some of the leads go to oil troughs directly under each connecting rod, one to the centre crankshaft bearing, one to the half-time gearwheel case, and another lead may be connected to a sight-feed on the bulkhead if it should be desired. The connecting rods have copper tubes on the bottom of crankpin big-ends. These tubes dip into oil in the troughs, taking oil through them to the crankpin bearings and splashing it as well to the other parts in the crankcase that require lubrication. The oil troughs are cast integral. The running speed of the heavy-duty commercial type is about 400 r.p.m., and different sized motors vary slightly in arrangement.

Some interesting power tests at different speeds were recently made with a Regal petrol engine of 32 rated horsepower on a Prony brake. At 800 r.p.m., 32.6 b.h.p. was developed; at 900 r.p.m., 35.8 b.h.p.; at 1050 r.p.m., 40.8 b.h.p.; at 1260 r.p.m., 45.5 b.h.p.; at 1315 r.p.m., 47.0 b.h.p.; and at 1506 r.p.m., 51.4 b.h.p.

The Scripps

This is an American engine, which was first brought into prominence in this country in connection with Mr. T. F. Day's voyage across the Atlantic in the 16 h.p. Scripps-engined cabin cruiser "Detroit" in the summer of 1912. It is now handled by Messrs. W. and S. Pollock, of Glasgow. Unlike many American engines, the Scripps is a four-cycle model, and is perhaps for this reason well suited to the British market. It is made in one, two, four and six cylinders with varying outputs from 4 h.p. to 96 h.p. All the models can be obtained arranged to run on paraffin with petrol starting. The cylinders are cast singly, and have heads and water-jacket integral. The crankcase is made in two sections, the lower half being extended to carry the reverse gear. Splash lubrication is fitted, equal level in all crank compartments being maintained by a series of ducts cast in the lower case. In the heavy type marine sets there is a combination of splash



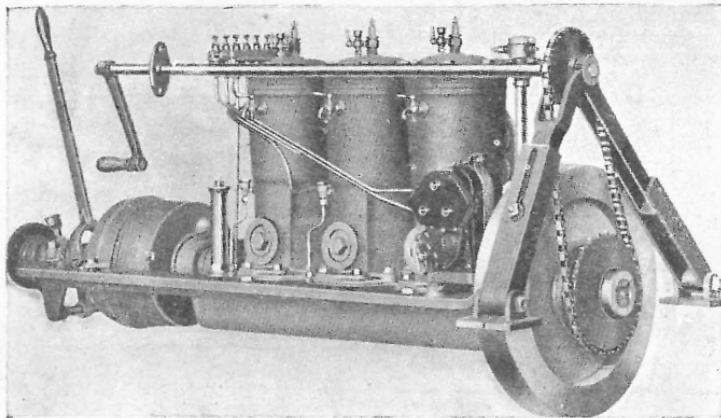
The Scripps engine.

and forced feed. The oil is forced from mechanical lubricator direct to each cylinder and main bearing, the surplus collecting in each crank compartment. Water-cooling is by gear pump or plunger pump as desired, but in the case of the heavy type engines the plunger pump is always fitted, and this is driven from an eccentric on the rear end of camshaft at half speed; all the pumps, in fact, on this model, including the air compressor when fitted, are driven from an eccentric gear.

Self-starters of the compressed air type can be fitted to engines of over 18 b.h.p., while the heavy duty sets of 50 b.h.p. and over are fitted with air self-starters as regular equipment. These self-starters, which are based on the Chalmers' patents, are designed to operate on as low as 40 lb. pressure, and the pressure is obtained from one of the combustion chambers. Two high-tension ignitions are fitted, battery and magneto, the latter being of the Bosch make.

The Ferro

This, again, is an engine of American construction, and it is marketed in Britain by Messrs. W. and S. Pollock and Co., of Glasgow. It is of the two-stroke type, and with the Ferro design the off-set cylinder principle has been adopted, which gives almost a straight line of impulse to the connecting rod, thus reducing the pressure against the cylinder walls. At the same time there is a tendency to allow more power to be developed by this method, owing, it is claimed, to the frictional resistance being less. The cylinder heads are detachable, and the walls and the crank-case are amply water-cooled by means of a plunger pump. After cooling the crank chamber the water is forced into the jackets near the exhaust pipe, which is the hottest part of the engine. From there it passes to the cylinder



The Ferro engine.

head, whence it is discharged into the exhaust pipe. One of the most notable features is the lubricating system, everything having been done to make it as efficient as possible. The oil is carried in a compartment cast integral with the crankcase, and a pressure indicated by a gauge is maintained by means of compression from the crank chamber through check valves. From the chamber the oil is forced to sight-feed lubricators, whence it passes to the bearings and other working parts, also the mixture intake. With regard to the latter, as an extra precaution the lubricating oil is carried, with the fuel mixture, through the intake ports to ensure of the piston being properly supplied. An additional safeguard is found in the splash-feed system, and to each of the connecting rods are fitted "dips," which scoop up the oil in the crank chamber, while the crankshaft is bored to maintain an extra supply to the main bearing. It is quite possible that minor

PARAFFIN-PETROL ENGINES

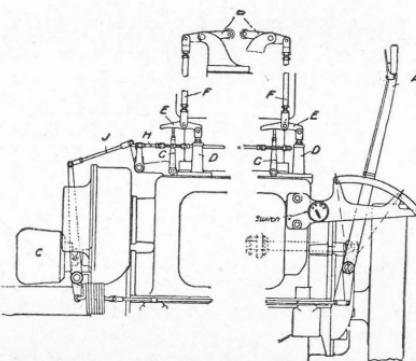
modifications may have lately been made to these arrangements, as the makers, the Ferro Machine and Foundry Co., are constantly bringing out fresh improvements.

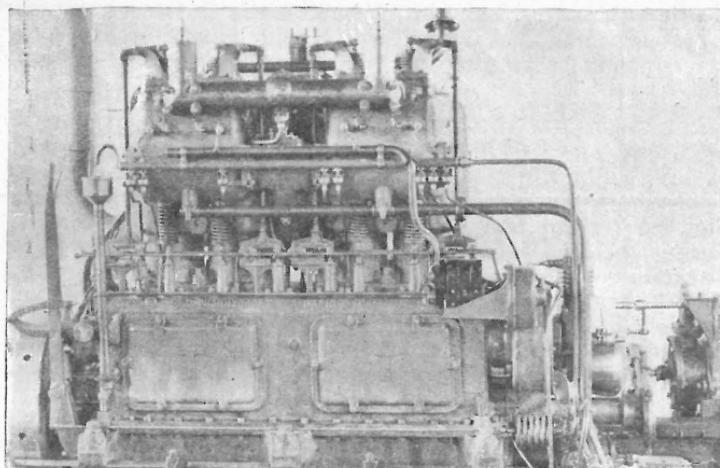
The Thornycroft

Thornycroft paraffin-petrol engines are built in standard powers from 7 h.p. to 150 h.p., although larger sizes have been made for special purposes, such as the 350 h.p. sets for the Italian Navy. All are of the four-stroke single-acting enclosed type with forced lubrication, and are non-reversible with the exception of the six-cylinder 150 h.p. direct reversing motor, which we propose to deal with as the most interesting. The makers are Messrs. John I. Thornycroft and Co., of London and Basingstoke. The inlet valves are arranged over the exhaust valves and are operated by push rods and rockers, while the exhaust valves are operated by tappets. The usual vertical exhaust-heated paraffin vaporizer is adopted, with float feed. To change over from petrol to paraffin there is a three-way fuel cock, and a by-pass valve for the exhaust gases. The fuel consumption is guaranteed at 0.9 pint per b.h.p. per hour, but in actual service is considerably less, whilst the running speed is 550 r.p.m.

The engine speed is regulated and raised by means of an arrangement which varies the inlet valve lift, the same being directly controlled by the governor and by hand. Referring to the sketch showing the fore and aft cylinder inlet valve control, this is duplicated for the others. B is the inlet valve rocker, and D the plunger worked by the cam on the camshaft, while F is an intermediate push-rod, connected to and worked by the rocker (E), which in turn rests upon the swinging support (G). It will be seen that the fulcrum of the rocker (E) depends upon the position of the support (G), and that the latter is connected to the governor (C) by the spring-controlled rods (J and H). By varying the fulcrum of the rocker (E), the lift of the valve (F)—consequently the inlet valve lift—is varied according to the engine speed. The hand lever (A) also controls the valve lift, and all the valve gear of the six-cylinders is controlled simultaneously.

Reversing is carried out by compressed air from storage tanks kept charged by a small air compressor driven off the forward end of the camshaft by a friction clutch. The air is supplied to the cylinders via a six-port rotating distributing





The Thornycroft 100 h.p. non-reversing engine.

valve, the latter being driven by a spiral wheel off the camshaft. When it is desired to reverse, the camshaft is moved fore and aft, which operation brings a duplicate set of cams into action under the inlet and exhaust valves. For ignition a single magneto is adopted, and an arrangement allows it to run in the same direction of rotation as the engine with correct timing. The shaft that operates the starting valves is extended across the back of the engine to drive the magneto by a double bevel wheel and pinion device, which, by means of the gear provided, rotates the magneto with the engine. This is carried out by means of a free wheel, so mounted that a pawl upon a plate keyed to the reversing shaft engages with a "laced" recess in the boss of the wheel. A duplicate pawl and recess are fitted to another plate that drives the magneto through a bevel pinion when the engine is running astern, and this pawl and recess are arranged for engaging in the opposite direction. The four-cylinder 100 h.p. non-reversing engine has a somewhat similar inlet valve control device as the 150 h.p. motor, the difference being that instead of the swinging support (G) there is a pulley running between two wedge-shaped surfaces, so it is only another method of obtaining the same results.

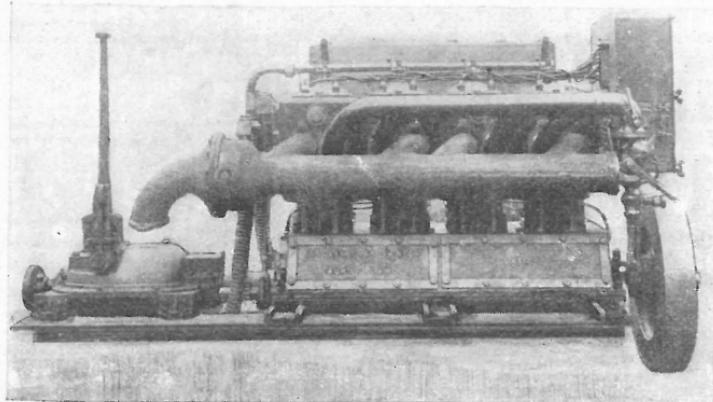
The Wear

While Wear engines are made in sizes from 4 h.p. to 100 h.p., the commercial paraffin-petrol motor, strictly speaking, is made in powers from 16 h.p. upwards. With the smaller sizes the cylinders are cast in pairs, while the others have cylinders cast separately. From 16 h.p. to 50 h.p. the speed is 650 r.p.m., and the 100 h.p. model turns

PARAFFIN-PETROL ENGINES

at 500 r.p.m., so we have a four-stroke machine of moderate revolution and weight. The valves are all on one side, and are of the large size. The cylinder water-jackets are carried well down, which has a good effect on the crankcase lubricating oil (an experience gained in the continuous running of these engines for days, in salvage work). The water circulation is maintained by plunger pump, driven from the cam-shaft. The fuel system is such that it can be used as an ordinary carburetter to run on petrol continuously. In the illustration, the larger handle is in position for petrol, being in direct communication with the petrol to carburetter-inlet pipe—and cylinders. By pressing the handle in a downward direction, the paraffin or heavier oils are brought into direct communication with the carburetter to the heating system placed in the exhaust pipe, back again to the carburetter—inlet pipe—and cylinders. This system has given exceptionally good results, on account of the breaking up of the vaporized fuel, and just previous to its entrance to the inlet pipe it is mixed with about 80 per cent. of the total air required—greater density, hence greater volume.

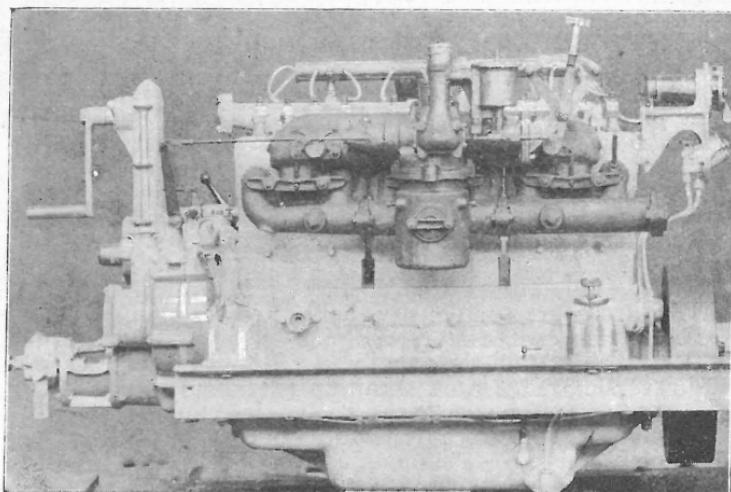
The engine can be started direct on paraffin by heating with a blow-lamp in the usual way. No water drip is used, and reversing is by gear. Ignition is either by magneto or coil and accumulator, or both. The engine can be started on magneto ignition direct by hand, cranking up to 40 b.h.p., half-compression release being used up to 60 b.h.p. Lubrication is by plunger pump from the sump (which is cooled by the circulating water before it enters the cylinders) to the lubricating-oil tank, supplying sight-feeds, to large oil cups, thence to the bearings. The makers are Messrs. Lindsay, Swan, Hunter, Ltd., of Sunderland, who are also salvage contractors, and as their engines are often running for days at a stretch without a stop, they have been able to gain knowledge of the requirements of a commercial motor.



The Wear engine.

Wolseley

Wolseley petrol motors are made in a great range of sizes from 10 h.p. to 400 h.p., but these we do not propose to deal with here, and there are in addition four standard paraffin engines—an 8 h.p. two-cylinder model, and three four-cylinder patterns of 10, 16 and 28 h.p. respectively,



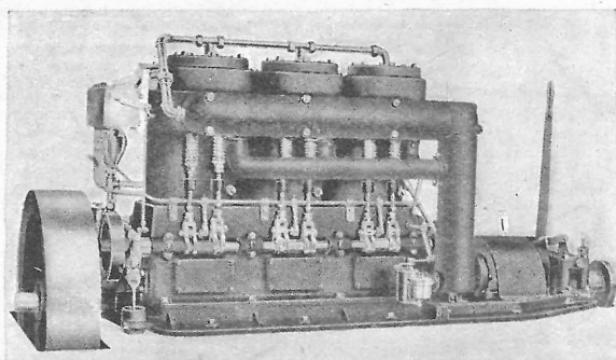
The Wolseley engine.

the normal speed being 900 r.p.m. in each case. All belong to the lighter and more compact class rather than to the heavy, slow-speed commercial type. The paraffin differ from the petrol engines principally in the arrangement of the induction and exhaust piping, the heat of the exhaust being utilized in the case of the heavier fuel to assist vaporization. Starting is effected on petrol, but a few minutes running suffices to generate enough heat for the change to paraffin to be made. A single movement of a piston slide valve accomplishes this result, a dual type of carburetter being fitted which is designed to use petrol or paraffin, as required. Very great care has been given to lubrication. There is the usual sump or well under the crankcase, from which oil is delivered by a pump to the main bearings and to troughs under the big-ends. These troughs are constantly supplied, and the excess simply overflows and drains back to the sump, the system making the supply quite independent of rolling or pitching of the vessel or of the angle at which the engine is installed. A very accessible oil filter is provided (shown above the left-hand bearer arm in the illustration). Bosch high-tension dual ignition is used, the magneto being used for running while the coil is available for starting. Water circulation

is maintained by a gear pump, placed very low down at the forward end of the engine, where it is easily accessible and at the same time well below the water line and free from any possibility of priming troubles. The oil pump, which in some engines is practically out of sight, is equally easily reached, being on the port side of the crankcase above the shaft line and driven by skew gear off the camshaft. Cylinders are cast in pairs with valves side by side. Thoroughly substantial control levers are fitted, and, finally, the starting chain is neatly enclosed in a case at the forward end of the engine. The fuel consumption on paraffin is 0.75 pint per b.h.p. hour. The makers are the Wolseley Tool and Motor Car Co., of Birmingham.

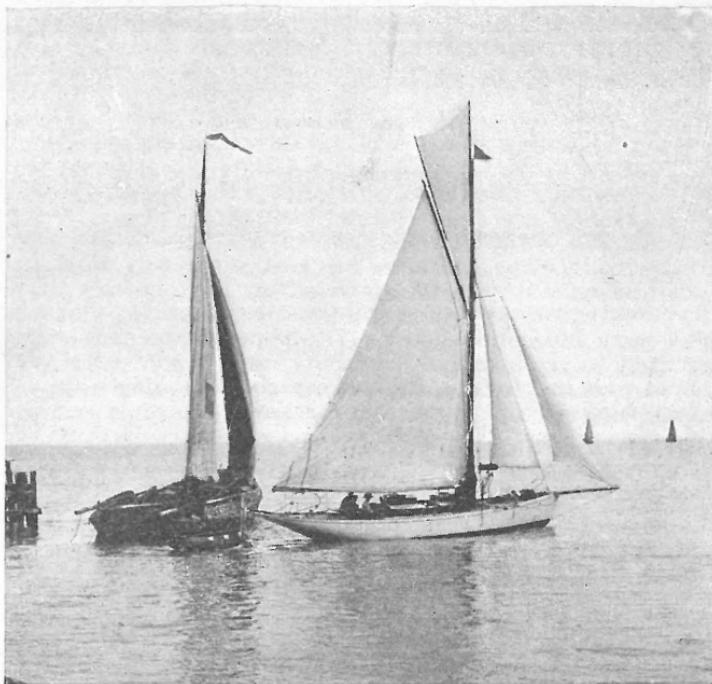
The Wolverine

One of the most noteworthy features in connection with Wolverine marine motors is that, apart from running on paraffin or petrol, they are largely used in connection with producer-gas installations, and we do not know of any other engine used for the purpose unless specially designed solely for suction gas. It is made in various sizes by the Wolverine Motor Works, of Bridgeport, U.S.A., and is handled by Messrs. Anderson and Caroe, of Glasgow. Of the four-stroke class, it is non-reversible, and is of the heavy-duty type, the three-cylinder 50 b.h.p. paraffin model turning at 300 revs. per minute. On petrol about 15 per cent. increase of power is obtained. The bore is $9\frac{1}{2}$ in. by 12 in. stroke. The cylinders are cast separately with the inlet and exhaust valves arranged on the one side, and are mounted on an ordinary enclosed crankcase, which is fitted with inspection doors. The poppet type valves are actuated by an exposed camshaft, and the ends of the tappet rods are forked, the forks each containing a roller, which runs on the cams. For starting there is a half-compression gear, the operation and construction of which



The Wolverine engine.

is of interest. The pin on which the exhaust tappet roller is pivoted is extended, and on it a collar is mounted. To this collar is attached one end of a lever, the other end of which can be moved fore and aft by means of a small hand lever. Upon moving the lever the collar attached to the tappet fork is moved on to an auxiliary cam, which thus raises the exhaust valve during the compression stroke and so allows the crankshaft to be easily turned. Removable heads are fitted to the cylinders, and separate removable covers to the valve-boxes for accessibility purposes. Lubrication is by a multiple sight-feed lubricator of the double-pump type, the latter being operated off an eccentric on the crankshaft extension. From the lubricator pipes, with adjustable feeds, are carried to the working parts. The same eccentric operates the plunger type water-cooling pump and a small air compressor.



BUSINESS AND PLEASURE.

An auxiliary fishing boat and an auxiliary motor yacht sailing out of harbour.

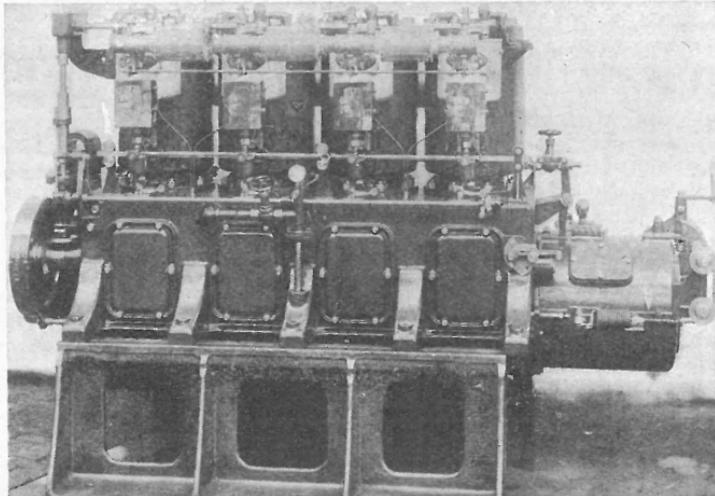
CHAPTER XIII

Paraffin Engines

(Without Petrol Starting)

The Gardner

THIS is purely a paraffin engine, no petrol being used for starting or running when desired, and the constant heat of the vaporizer is its most striking feature. The exhaust valves are on the opposite side of the cylinder to the inlet valve. To each inlet valve chamber there is a separate vaporizer, which is continually kept hot by a small external lamp, leaving the cylinder, the cylinder head, and the exhaust connections free to be thoroughly water-jacketed. All that is necessary to start up a Gardner engine is to light these lamps. Once the engine is running, the heat applied to the vaporizer and the oil is absolutely constant, whether the load be light or heavy—and as this constant temperature of the vaporizer is designed to be the most suitable for the class of oil which is to be used—the vaporizer is always at its best temperature and not subject to any variation according to the load on the engine. Paraffin is supplied to the



The Gardner engine.

lamps under pressure, a small ram pump, geared to the engine, drawing fuel from the main tank and forcing it under a low pressure into a small container. As the inlet valve opens, oil is sucked through, and, being immediately vaporized in the hot chamber, forms a rich mixture with the small quantity of air admitted there. As the piston descends on the suction stroke, a snifter valve in the centre of the cylinder crown also opens, admitting a small quantity of air and water to mix with the gas already in the cylinder.

Governing is arranged by varying the lift of the inlet valve and thus controlling the engine speed by checking the amount of mixture that is drawn into the combustion chamber. Control of the governor is either by hand or is automatic. The method of varying the valve lift is as follows: Between the valve stem and the plunger from the camshaft is a swinging pointer suspended from a horizontal rod connected with the governor, and the position of this pointer is determined by the action of the governor, which in turn is controlled by the engine speed. The upper end of the pointer actuates the inlet valve, while the lower end is operated by a "bridge" or ratchet, the latter being raised and lowered at one end by the plunger from the cam, while the other end is hinged. The side of the "bridge" nearest the plunger is notched, and at the other side is a step. Over these notches and over the step the pointer swings, and as the governor determines its position, the length of its stroke, and, incidentally, the opening of the inlet valve is so regulated. When over the step there is a complete cut-out, and the inlet valve does not open.

The standard ignition system of the Gardner engines is low-tension magneto, so arranged and set that it will spark well at the slowest speeds. In the two smaller series of Gardner engines the lubrication is effected by splash, a special device being used for oiling the piston and wrist pins and a centrifugal lubricator being fitted for each crankpin. In all the larger engines forced lubrication is employed, the oil being delivered under a pressure of 15 lb. per sq. in. to all the principal bearings in the crankcase, including also the big—and small—ends of the connecting rods. Doors are fitted to the crank chamber, to provide access to the bearings, and accessibility has been well studied to every part. In consumption, the Gardner engines are economical, the amount of petroleum used per b.h.p. hour being in the region of 0.65 of a pint, while the running speed is about 600 r.p.m., varying according to the power. The makers are Messrs. Norris, Henty and Gardners, Ltd., of London and Manchester.

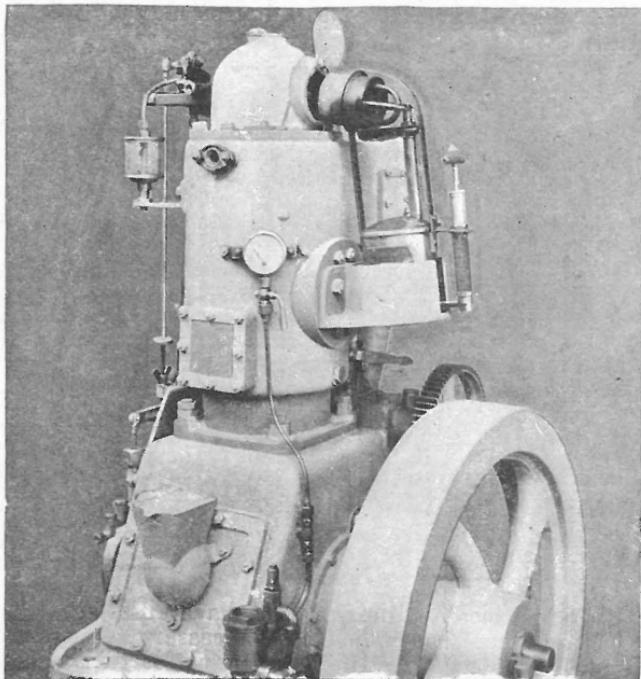
The Brooke

This is a four-stroke engine of extremely accessible design as regards its main features, and has, so far, only been manufactured in one type, having one cylinder and developing 10 h.p. The engine is of the enclosed crankcase type, the bearer arms being at the bottom of the case; the usual

PARAFFIN ENGINES

trunk piston construction is followed, and both inlet and exhaust valves are mechanically operated and placed side by side. Ignition is effected by hot bulb, the paraffin fuel being injected direct into the bulb, while the air supply reaches the cylinder through the inlet valve. The fuel is supplied by a plunger pump, and the injection is timed to take place just before the end of the compression stroke; in fact, the moment of injection corresponds to what with electric ignition would be the moment of firing. The engine is non-reversible.

The initial heat for starting is supplied by means of a blow-lamp, and, when once started, the engine will continue to run either at full load or light without further use of the lamp, a portion of the heat generated by the explosions in the combustion chamber being utilized in keeping the ignition bulb hot. Governing is effected on the hit-and-miss-the-pump system. The engine is very flexible and can be regulated in speed by altering the length of stroke of the fuel pump by means of a set-screw and lock-nut. A hand lever is fitted on the left side of the engine, which is used to give a stroke initially to the pump and so inject fuel for starting. The complete pump gear is attached to the engine by three nuts only, so that, should



The Brooke engine.

any repairs be required, the whole apparatus can be quickly taken apart. For starting, a compression relief device is fitted, which consists of a special gear fitted to the inlet valve. A lever is shifted underneath, a pin projecting from the side of the valve tappet, whereby the valve itself is held off its seating, and the engine is turned in the reverse direction to that in which it is intended to run. So soon as sufficient momentum has been gained, the lever is pulled cleared of the pin, thus allowing the valve to drop back on its seating. The engine then continues to turn until it comes back on the compression stroke, when the charge is automatically fired and the engine starts off in the right direction. The makers are Messrs. J. W. Brooke and Co., of Lowestoft, who also construct a large range of petrol marine engines, many of which can be fitted with paraffin vaporizers if desired.

CAPACITY OF ROUND TANKS

The following table giving the capacity of round tanks may be of value to fishing boat and barge owners who are deciding to install auxiliary motor power. The figures quoted will enable them to determine exactly what space will be required for given quantities of fuel. Five per cent. has been deducted, so the figures may be taken as practical.

Diameter in inches.	Gallons per inch.	Sp. G. .73	Petrol.	Weight in lbs. per inch.						Water.
				.796	.81	.85	.895	.93	1.0	
6	.0969	.7074	.7713	.7849	.8236	.8672	.901			.969
6½	.1134	.8278	.9028	.9186	.964	1.015	1.055			1.134
7	.1304	.9520	1.038	1.056	1.108	1.167	1.213			1.304
7½	.1514	1.105	1.205	1.226	1.288	1.355	1.408			1.514
8	.1719	1.255	1.368	1.393	1.461	1.539	1.599			1.719
8½	.1943	1.418	1.547	1.574	1.651	1.739	1.807			1.943
9	.2180	1.591	1.735	1.766	1.853	1.951	2.027			2.18
9½	.2425	1.77	1.930	1.964	2.061	2.170	2.255			2.425
10	.2690	1.94	2.149	2.186	2.294	2.416	2.510			2.69
10½	.2968	2.166	2.353	2.404	2.523	2.656	2.76			2.968
11	.3253	2.375	2.589	2.635	2.765	2.912	3.026			3.253
11½	.3557	2.597	2.831	2.881	3.023	3.183	3.307			3.557
12	.3876	2.829	3.085	3.14	3.294	3.469	3.605			3.876
13	.4146	3.319	3.619	3.683	3.864	4.069	4.228			4.546
14	.5270	3.847	4.195	4.269	4.48	4.717	4.901			5.270
15	.6057	4.422	4.821	4.906	5.148	5.421	5.633			6.057
16	.6887	5.027	5.482	5.579	5.854	6.164	6.405			6.887
17	.7772	5.673	6.187	6.295	6.606	6.936	7.228			7.772
18	.8722	6.376	6.942	7.064	7.414	7.806	8.112			8.722
19	.9712	7.09	7.73	7.866	8.256	8.692	9.032			9.712
20	1.076	7.855	8.566	8.716	9.146	9.632	10.07			10.76
21	1.187	8.665	9.45	9.616	10.09	10.62	11.04			11.87
22	1.302	9.504	10.36	10.55	11.07	11.65	12.11			13.02
23	1.423	10.39	11.33	11.53	12.10	12.74	13.23			14.23
24	1.550	11.32	12.34	12.56	13.18	13.87	14.42			15.50

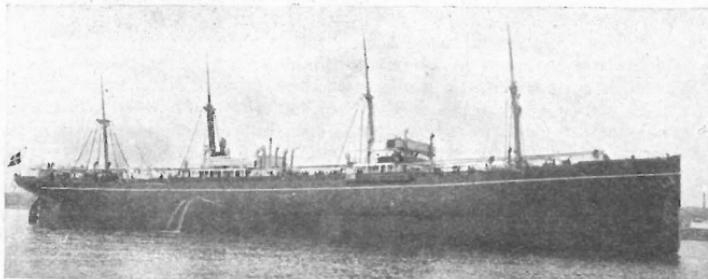
It will be noticed as different fuels have different weights for the same quantity, it has been necessary to sub-divide the figures into tables. The best metal for fuel tanks is seamless steel electrically welded, such as is made by the Steel Barrel Co., of Uxbridge.

CHAPTER XIV

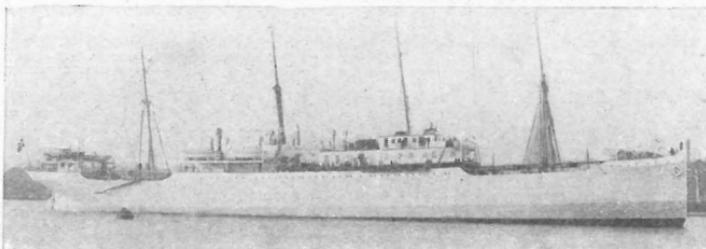
Types of Commercial Motor Craft

DURING the last few years the marine internal-combustion engine, particularly the paraffin and heavy-oil types, has made a wonderful development, so far as its adoption for commercial craft is concerned, and, for nearly every class of boat and vessel, the motor has been a serious competitor with steam machinery. In fact, in some classes of boats steam has no comparison from an economical point of view. In the following pages we give some interesting examples of craft in which motors have successfully been employed.

LARGE MOTOR SHIPS



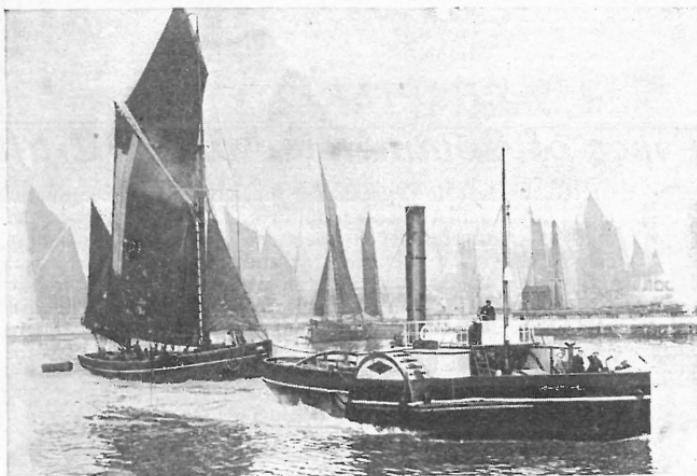
The most recent development of the heavy-oil engine—the large ocean-going cargo motor ship. The vessel illustrated is the "Siam," a ship of 8900 tons d.w.c.; fitted with Diesel engines of 3000 h.p. Length, 410 ft.; beam, 55 ft.; draught, 20½ ft.; speed, 11½ knots.



"Fonia," the ninth large motor ship built by Messrs. Burmester and Wain. She is the highest-powered oil-engined vessel in the world, being fitted with two 2000 i.h.p. Diesel engines. Length o.a. 410 ft., beam 53 ft., depth 38 ft., d.w. capacity 7000 tons, speed 14½ knots. She carries passengers and cargo.

MARINE OIL ENGINE HANDBOOK

WHERE A MOTOR IS WANTED



As she has no auxiliary motor installed, this fishing vessel has to pay the steam tug to tow her out of harbour each trip. To enable her to put out of harbour it would cost but a few pence if she had a motor, whereas the steam tug has to be paid a very large sum comparatively.

MOTOR FISHING BOATS



Practically every fisherman is now asking for State aid in getting a motor for his boat, whereas a few years ago the fishermen were strongly prejudiced against the new power. The articles in "The Motor Ship and Motor Boat" during recent years have at last convinced him that with a motor the earning powers of his boat can be increased from 30 to 150 per cent.

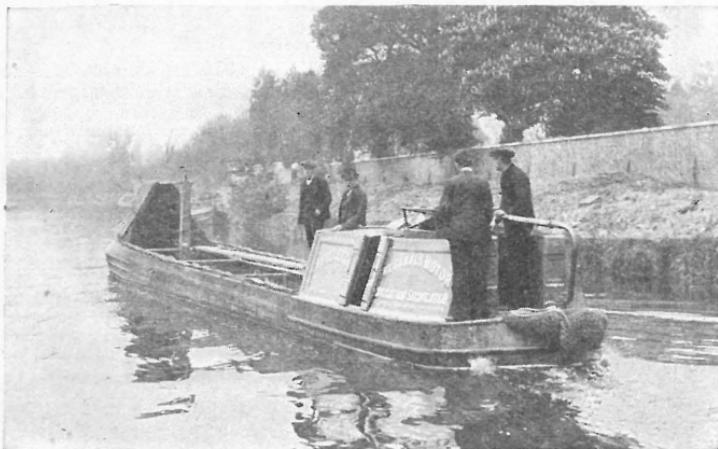
TYPES OF COMMERCIAL MOTOR CRAFT

THAMES SAILING BARGES



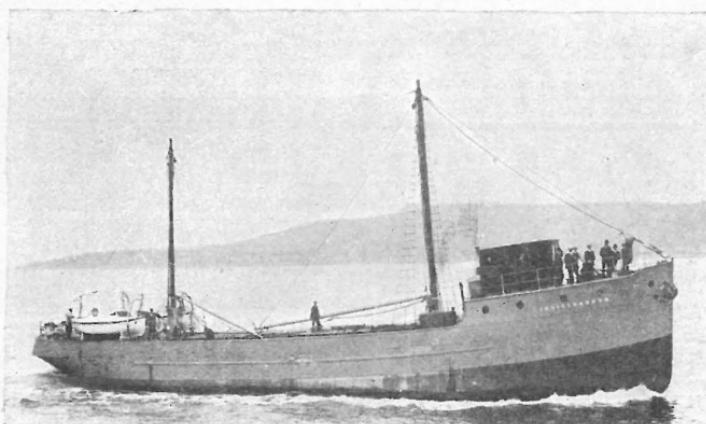
“Grit,” the first Thames sailing barge to be provided with auxiliary motor power. The engine occupies but little space and enables the boat to carry out her duties independently of wind and tide. The engine is a 45 h.p. Kromhout, and was installed in 1913.

CANAL MOTOR TRANSPORT



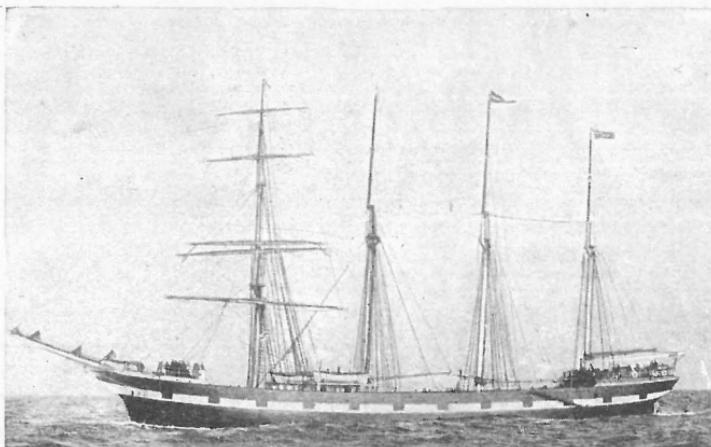
A “narrow,” or monkey, barge in service on the canals of England. She is fitted with a 15 h.p. Barcar paraffin-petrol motor, and the fuel consumption works out at less than 1-20th of a penny per ton-mile. She can carry 30 tons of cargo at an average speed of $4\frac{1}{2}$ miles an hour. The propeller turns at about 250 r.p.m.

COASTING CRAFT



Apart from fuel economy, the motor in coasting work enables a vessel to carry considerably more cargo for the same dimensions than a full-powered steam coaster. This vessel is 175 ft. long by 21 $\frac{1}{2}$ ft. beam and 10 $\frac{1}{2}$ ft. moulded depth. Her engine is a 220 h.p. Beardmore of the hot-bulb type. Speed, 9.25 knots.

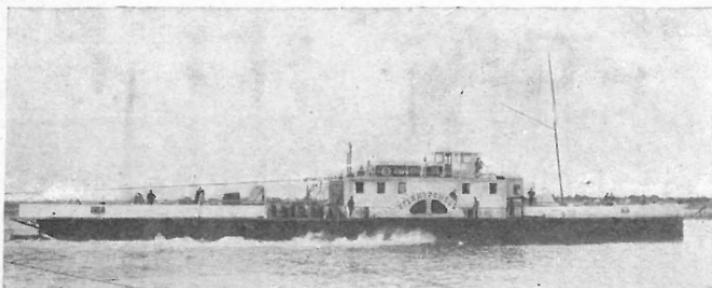
SEA-GOING AUXILIARIES



Motor-driven auxiliary sailing ships are now in service up to 10,000 tons. The above vessel, the "Sound of Jura," is a 2000 h.p. barquentine, fitted with a 260 h.p. Polar-Diesel oil engine. A point of historical interest is that the "Fram," which carried the Amundsen expedition to the South Pole, was fitted with a 180 h.p. auxiliary Polar-Diesel motor.

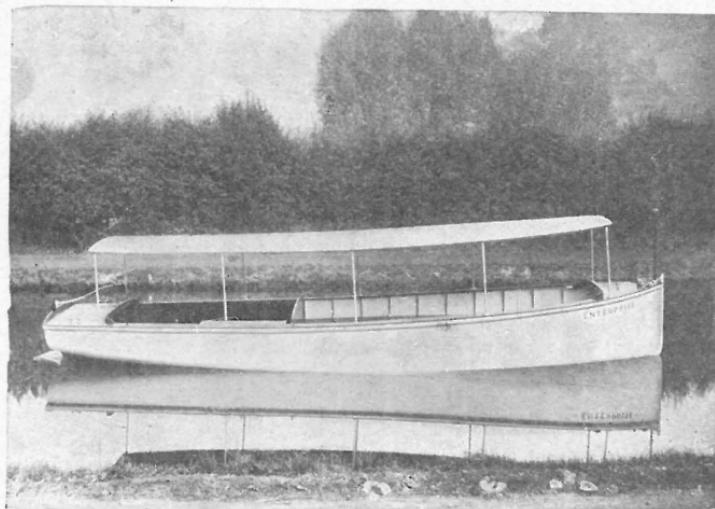
TYPES OF COMMERCIAL MOTOR CRAFT

RIVER PADDLE TUGS



A double-ended paddle tug on the Volga, driven by two 300 h.p. Kolomna-Diesel engines. The advantage of this type of vessel is felt in narrow rivers, as she can tow ahead or astern with equal efficiency, and so avoid turning round. There are quite a number of vessels of this type in Russia with oil engines varying from 150 h.p. to 600 h.p.

SMALL STEEL LAUNCHES



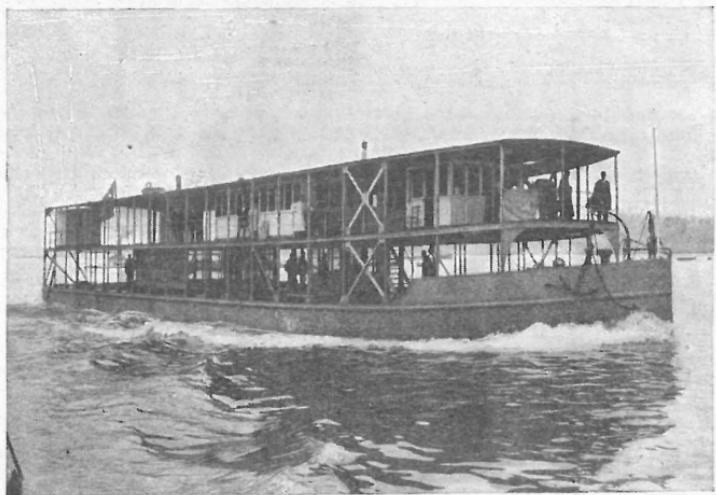
Owing to the small amount of room required for the machinery, a motor-driven launch of this type can carry a considerable amount of cargo for her size. The "Enterprise," a 30 ft. by 7 ft. by 3½ ft. steel launch, fitted with a 20 h.p. British Buffalo motor. Capacity, 5 tons; speed, 7½ knots; fuel consumption, 1½ gallon per hour.

FIRE SERVICE



Motor-driven fire-floats are rapidly superseding steamers, as the light weight of the machinery allows the vessels to be of very shallow draught. This is the "Delta," now in service on the River Thames. She is driven, and her pumps are operated by, three Kromhout 56 h.p. paraffin-petrol motors. Length, 100 ft.; beam, 21½ ft.; draught, 2 ft.; speed, 10½ knots.

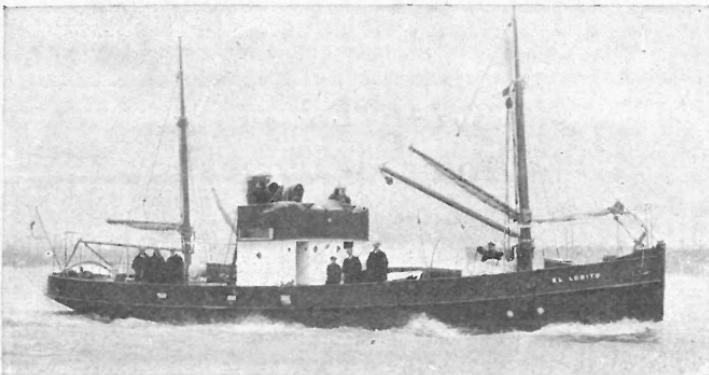
SHALLOW-DRAUGHT CRAFT



By reason of the light weight for the power developed, thus giving moderate displacement, the oil motor has no equal for shallow-draught boats. We have here an oil-engined shallow-draught vessel built for service on the Congo. Some of these vessels are stern wheelers, others are of the tunnel-stern class with screw propellers.

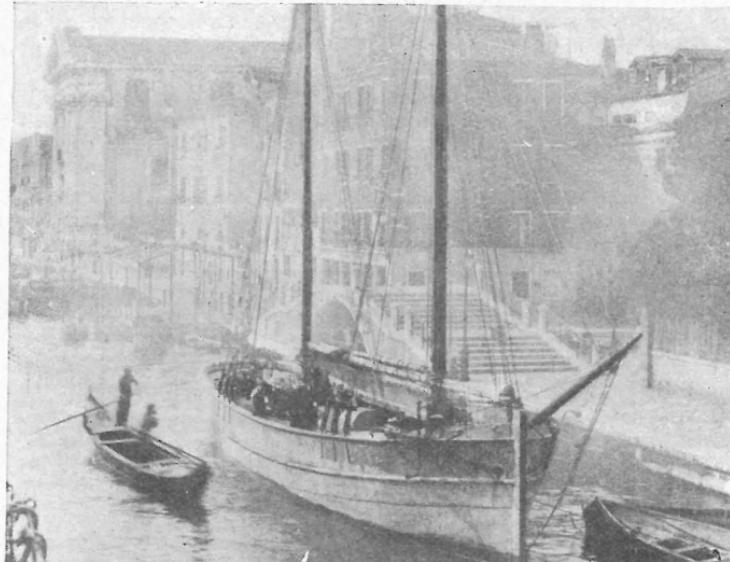
TYPES OF COMMERCIAL MOTOR CRAFT

GENERAL SERVICE BOATS



The "El Lobito," a general-service and cargo vessel, built by Thornycrofts for use abroad. She is 75 ft. long by 16 ft. beam and 6 ft. 10 ins. draught. With two 100 h.p. paraffin-petrol motors her speed is nine knots, and she can carry 50 tons of cargo and has good accommodation.

DIESEL-ENGINED FISHING VESSELS



For large fishing vessels there is a field for Diesel engines, and many have already been fitted, including the above boat, which is equipped with a 100 h.p. Kind-Diesel motor. The Frerichs Co., of Osterholz-Scharmbek, also have fitted a number of fishing craft with Diesel engines of the Junkers type.

CHAPTER XV

Motor Winches

IN connection with the progress which the marine internal-combustion engine has made for the propulsion of ships, one of the points which has always struck the onlooker as an anachronism is that a boiler is so frequently installed in cargo vessels, where a motor is used for the purpose of propulsion. This is usually owing to the necessity for driving certain auxiliaries, as, until recently, it was generally considered that steam was the only possible means of operating such accessory machinery. Another reason was that with craft plying in certain districts where severe cold has to be endured for many months of the year, it is necessary, or advisable, to have a boiler for steam heating the ship. Consequently, it is only natural the steam thus generated should be applied for other uses, such as operating the auxiliaries.

This being so, manufacturers' energies took the form of improving the propelling engine rather than producing a perfect and reliable motor-driven winch, also because the latter was a secondary matter. However, within the last year or two a change has come over general opinion, and motors are now being more commonly employed for the driving of winches and similar purposes. Steam-driven auxiliaries are invariably extremely uneconomical, due to the inefficient oil-fired boiler, and this necessarily largely detracts from the economy which might be obtained with a motor vessel. Moreover, such machines are not immediately available, as is the case when they are motor-driven, and, in fact, it is easy to point out numerous advantages in connection with motor auxiliaries.

It may, then, pertinently be asked why, with all these advantages, the motor winch has not made more rapid headway. Like most other questions in connection with marine installation, the main point which has to be achieved before any machine is called a success is undeniable reliability. In earlier days motor winches were looked at askance because it was considered that they could not be nearly so reliable as steam-driven winches; but now, after a few years uphill work, the builders of such machines are finding that they are received with more general favour following upon the results of past experience.

Various types of motors are used for driving the winches, some having petrol engines, others paraffin, but it is to the heavy-oil class to which the future development can be looked for, as the majority of cargo vessels use this fuel for the main propelling engines, and so it is desirable that

MOTOR WINCHES

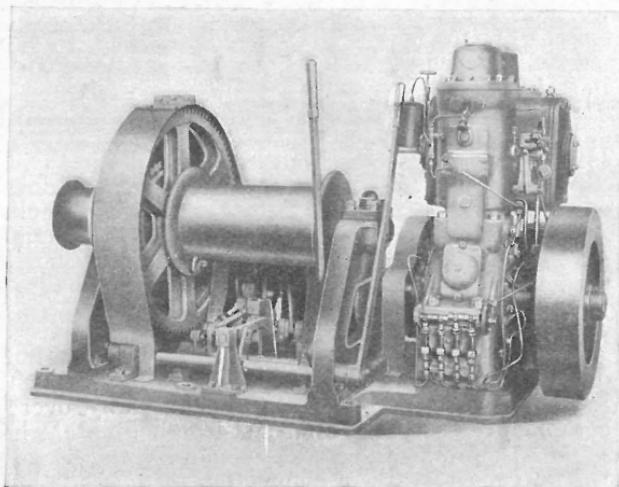
all auxiliaries shall work on the same oil. It will be found that practically all makes are self-contained, with the complete driving unit on deck; whereas in the case of a steam winch it is necessary to run a steam pipe from the boiler room, as a donkey boiler on deck would be cumbersome. So in this respect alone the motor winch has a decided advantage. Again, motor winches are very valuable for sailing vessels which are not fitted with mechanical propulsion power.

The Bolinders-Cyclops Winch

An example of the self-contained type of motor winch is to be found in the set produced by the Bolinders Co., which consists of a winch, driven by a single-cylinder Bolinders oil engine, very similar to the marine type which we have already described in the Heavy Oil Engine Section of this book, but non-reversible. To render the set self-contained, the water-cooling circulating pump is driven direct, and there is also a cast-iron silencer and fuel tank, the whole set being mounted on one cast-iron bedplate, which arrangement reduces the weight and space required.

The motor drives the winch through a double-purchase spur gearing, consisting of a pinion keyed on to the crank-shaft, gearing into a spurwheel. This spurwheel is itself keyed on to an intermediate shaft, gearing into a spurwheel on a barrel shaft. The pinion on the intermediate shaft is fitted with a friction clutch of the expanding ring type, and the winch is so arranged that only one lever is required for operating.

The method of operating is, briefly, as follows. When the lever is in the mid position, the motor is entirely free.



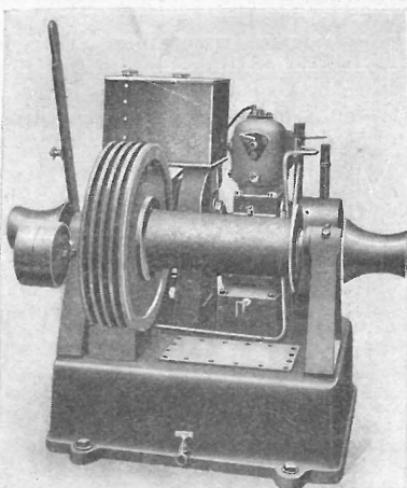
Bolinders-Cyclops winch.

A forward movement of the lever engages the friction clutch for raising the load, and the opposite direction for lowering the load on the brake. When it is required to lower the hook in an empty condition at a rapid speed, a reverse motion is brought into play, consisting of a chain drive worked by a friction cone clutch. Naturally, it is an important point to be able to lower the empty hook very rapidly, and this enables cargo to be dealt with much more quickly than would otherwise be the case.

The winch is fitted with a warping end and brake gear for lowering. The side frames and bearing brackets are of cast-iron, with adjustable keeps for the bearings, and gun-metal bushes are used in the first motion shaft. The control levers are at one end, close to the motor, so that the winchman has complete control of the winch and motor. The strap brake is of a powerful kind and is lined with Ferodo strips. The second lever, which is used for lowering at a rapid rate, is interlocked with the main lever, so that they cannot be operated together. The motor will run on the usual heavy fuels, such as gasoleum, shale oil, etc., and is provided with a heavy flywheel and a powerful clutch of 10 in. diameter. A winding barrel, having a diameter of 8 ins., is used. The cast-iron bedplate carrying the equipment of one model is 4 ft. 5 ins. long by 3 ft. 9 ins., and is arranged to be held down by six $\frac{1}{2}$ in. bolts, while the greatest overall width, including the barrels, is 6 ft. 3 ins. The power of the engine, of course, varies with the load that is desired to be lifted. The makers are the Bolinders Co., of Stockholm.

The Smart and Brown Winch

In the Smart and Brown winch we have a simple but serviceable model, in which the slipping clutch problem—for long a stumbling-block—has been successfully overcome. The equipment is mounted on a cast-iron bedplate, which is hollow, and contains the cylinder cooling water, so that there is no need to carry a connection on board; thus the set is entirely self-contained. The winch itself is merely a drum driven directly off the engine by a large friction pulley



Smart and Brown winch.

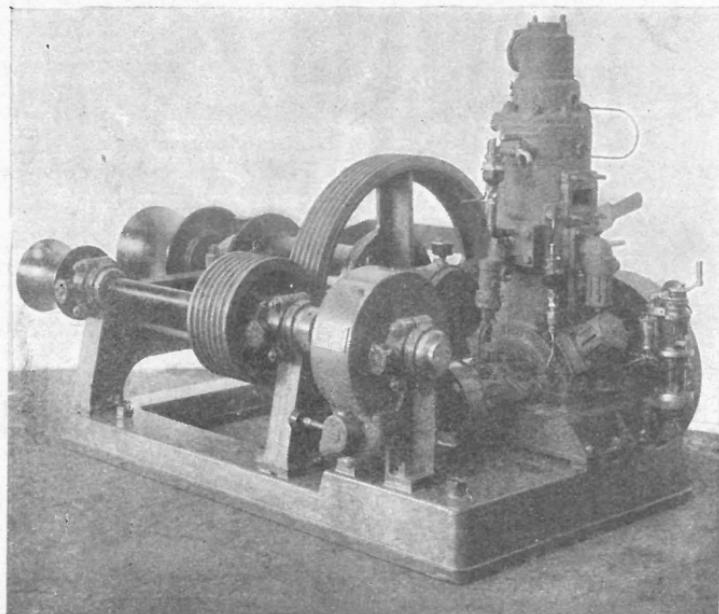
MOTOR WINCHES

that is entirely controlled by one lever, the latter throwing the friction drive in or out of action as desired. On the rim of the friction drum there are four deep grooves, which interlock with duplicate grooves on the driving pulley.

Regarding the driving engine, this is a single-cylinder model of the four-stroke type, 4 in. bore by 4 in. stroke, and it develops 4 h.p. at 950 r.p.m., paraffin or petrol being used as fuel. High-tension Bosch magneto ignition is fitted as standard. Over the engine is a double tank of three gallons capacity, allowing for two gallons of paraffin and one of petrol, or sufficient for about nine hours running. There is also a live pulley fitted on to the engine crankshaft extension, so that, if desired, it can be used for other purposes, such as driving a pump by means of a belt. This set can lift 5 cwt. at 140 ft. per minute, and is capable of unloading a 100-ton coal cargo in a day. More powerful models are made, but larger engines are fitted. The makers are Messrs. Smart and Brown, of Erith.

The Tuxham Winch

Another winch operating on similar lines to the one just described is the Tuxham, although the general arrangement is somewhat different. In this case, however, the drive is not direct, but is through enclosed gearing, while the driving engine is of the heavy-oil type, and, again, it is much

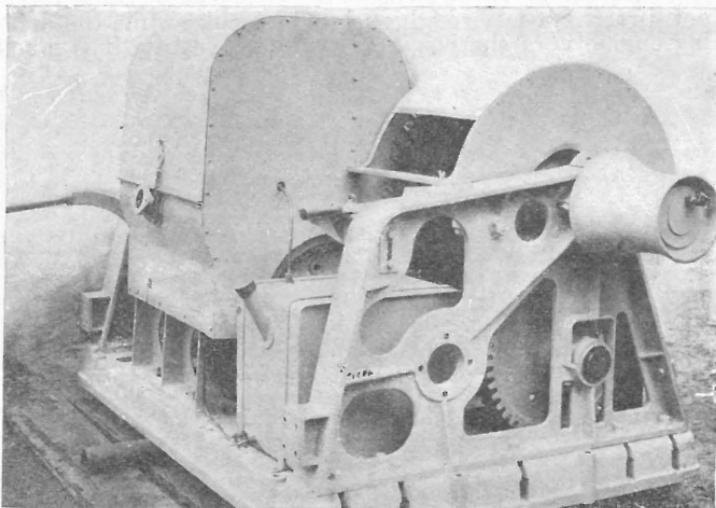


The Tuxham winch.

larger. It is a 7 h.p. hot-bulb type single-cylinder engine, similar to the Tuxham engine described in the heavy-oil engine chapter, with the difference that no water injection is used; but the bulb and the cylinder cover are, presumably, water-cooled. The winch is brought into action by a single lever, and, if required, may be fitted with a chain pulley for raising the anchor. The capacity is half a ton, at a speed of one-third metre per second, or about 66 ft. per minute. Other models up to 15 tons capacity are made. A governor is usually fitted to the engine, so that this portion requires little attention, allowing the man in charge to devote attention to the operation of the winch. The makers are the Tuxham Maschinfabrik, of Copenhagen.

The Djinn Winch

Three standard sizes are listed by the makers of the Djinn winch, the smallest lifting 10 cwt. at 80 ft. per minute, the next lifting 20 cwt. at 60 ft. per minute and 10 cwt. at 120 ft. per minute, and the largest having three speeds with lifts of 40 cwt., 30 cwt., and 12 cwt. at 45 ft., 85 ft., and 210 ft. per minute respectively. The design of the machine itself follows steam-winches lines as closely as possible. Each

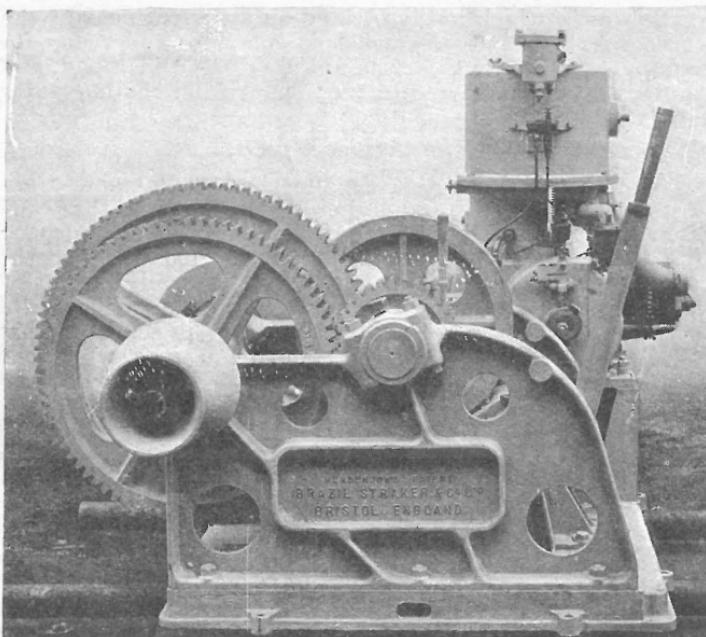


The Djinn winch with casing

winch has two warping drums and a gypsy wheel for working the windlass by a messenger chain. The motor in each case is a single-cylinder Djinn paraffin engine of similar design to the Djinn marine motor, as described in the paraffin-petrol engine chapter.

The motors used in the different sizes are of 5 b.h.p., 9 b.h.p., and 12 b.h.p. respectively, and each is completely

MOTOR WINCHES



Djinn winch with casing removed.

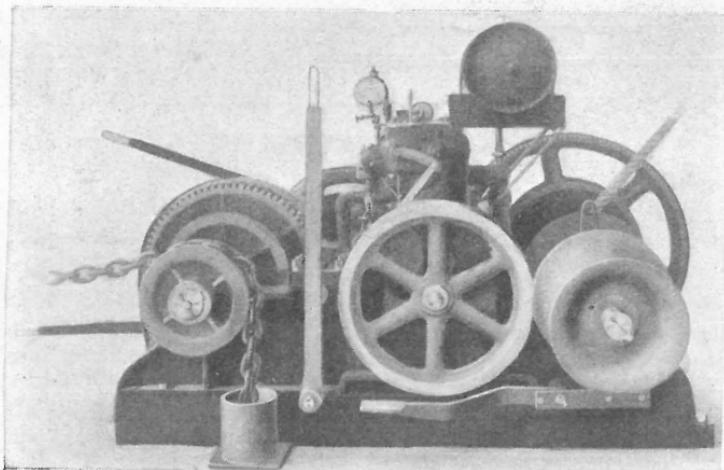
enclosed in a stout sheet-metal casing, which renders the engine next to watertight and protects all parts from mechanical injury. Access to the working parts is provided by sliding doors on the various sides, and the top of the case is hinged. Besides being governed, a hand throttle is fitted, so that when standing by, the motor can be slowed down for a few minutes. Starting is effected by petrol and change-over cock or by hand lamp, both being fitted. The power is transmitted to the winch gear by Henderson's patent transmission gear, which gives an interlocked lifting and braking control, and at the same time prevents all risk of the engine crankshaft being damaged by rough or careless handling, the only stress imposed on the crankshaft being a simple torque. The brake is adjustable by means of one pin, which allows wear to be taken up until the brake block is practically worn away.

As regards actual practice, the Djinn motor winch has shown some great economies in the cost of unloading. The French motor ship "Inski," which is equipped with one of these winches, unloaded 1600 bags of grain, each containing four bushels, in $4\frac{1}{2}$ hours, using less than half-a-crown's worth of fuel, heaving only two bags at a lift, the winch being capable of lifting eight or ten bags at a time if required. Each winch motor is tested in the ordinary manner for power, fuel consumption, etc., being afterwards fitted

to the winch, which is then tested on a derrick gear at the works. As sent out, the winch is complete and ready for running, with its fuel tank mounted on the winch bed, and has only to be connected to the silencer and cooling water supply.

The Atlas Winch

Probably the Atlas Gas Engine Co., of Oakland, California, has manufactured larger motor winches than any other firm, one of the sets that they built being operated by a four-cylinder distillate-fuel engine of 150 h.p., and the complete equipment weighed 35 tons. Naturally this was a very special job and not a standard plant. As a matter of fact, the variety of types they construct is so great that they build to order only. The standard designs, which can



Atlas combined winch and anchor windlass.

rapidly be made, however, are one 5 h.p. friction-driven model with a single-cylinder engine, and 8 h.p., 12 h.p., 16 h.p., and 20 h.p., with two-cylinder driving engines. The latter are built in two types, one being for derrick work and the other for marine purposes. The last-named has, in addition to the friction-drum drive, gypsies and "wildcats" for hoisting anchors.

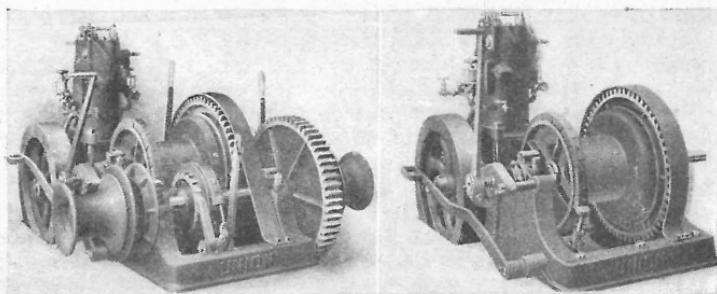
The illustration shows one of the Atlas two-cylinder-type ship's winches, having the friction drum in the usual manner for handling cargo. This drum is equipped with a brake and a pawl for holding the load, when required, for any length of time. It has two large gypsies for heaving in lines. The "wildcat" shaft is run at slow speed, in order to handle the anchors properly, and is driven by independent friction. This shaft also has a brake and pawl. It will be noticed that the fuel tank is arranged overhead.

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The Union Winch

Two types of winches are built by the Union Engine Co., of San Francisco, one having warping barrels attached for use when the vessel is docking, while the other is without this device. The latter is made in 3 h.p., 6 h.p., 9 h.p., 16 h.p., 25 h.p., and 30 h.p., the first three having single-cylinder driving motors and the others twin-cylinder engines, the running speed of the same being 600, 400, 400, 400, 280, and 280 respectively, while the revolutions of the drum are 80, 38, 32, 25, 26, and 26 per minute. The hoisting capacities of these various sizes are as follow:—500 lb. at 100 ft. per min., 1200 lb. at 100 ft. per min., 1600 lb. at 130 ft. per min., 2400 lb. at 150 ft. per min., 3000 lb. at 185 ft. per min., and 3600 lb. at 185 ft. per min. The smallest of these weighs about $6\frac{1}{2}$ cwt. net and the largest about $78\frac{1}{2}$ cwt. It is of great interest to note that all these lifting capacities may be doubled by using a double fall, but with such an arrangement the hoisting speed will be reduced by one-half. The engines used for operating purposes are generally designed to use distillate oil as fuel, which is between paraffin and petrol in specific gravity. Thus, in order to provide the heat necessary to allow of this fuel being used with success, the air is warmed by the exhaust gases before being led to the carburetter, and the induction pipes are also exhaust heated.

Regarding the winch with warping barrels, or windlass as it may be termed, this is built in two models, having single-cylinder engines of 6 h.p. and 9 h.p. respectively at 400 r.p.m. The higher-powered set of the two has a direct lift of 1600 lb. at 675 ft. per min., and an anchor cable speed of 16 ft. per min., with a direct lifting power of almost 90 cwt., the net weight of the equipment being just over 39 cwt. Again, the smaller set has a cargo-lifting capacity of 1200 lb. at 400 ft. per min., and an anchor cable raising speed of 13 ft. per min., with a direct lifting power of a little over 71 cwt. It weighs 2450 lb. net. In these cases also the lifting capacities can be doubled by using a double fall.



Union winches with and without combined windlass.

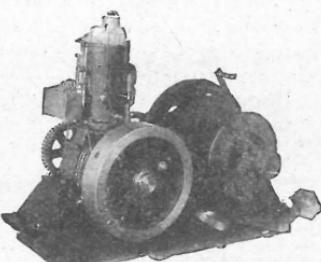
MARINE OIL ENGINE HANDBOOK

The Remington Winch.

It will be seen that winches apparently have had more attention paid to them in the United States than in this country up to the present time, and another American example is the Remington, which is made in six models as follow:—

Horse Power	6	9	10	15	20	30
Diam. of Drum	9"	9"	9"	12"	9"	12"
Face of Drum	12"	12"	12"	12"	20"	20"
Load	1000 lbs.	1500 lbs.	2000 lbs.	2000 lbs.	2000 lbs.	2000 lbs.
Rope Speed per min.	150 ft.	150 ft.	150 ft.	200 ft.	200 ft.	200 ft.
Net Weight	1900 lbs.	2000 lbs.	3000 lbs.	3250 lbs.	5700 lbs.	6100 lbs.
					Double Drum	Double Drum

The illustration given is of the 9 h.p. set, which is driven by a single-cylinder Remington hot-bulb oil engine of the two-stroke type. This set has a capacity of about 3½ cwt. single whip at a speed of 150 ft. per minute. The engine is fitted with a governor acting directly on the fuel pump, and so the fuel supply diminishes or increases in accordance with the load, so that the engine requires but little or no attention whilst operating the winch. It will unload 20 tons of coal per hour.



The Remington.

The Torbinia Windlass and Winch

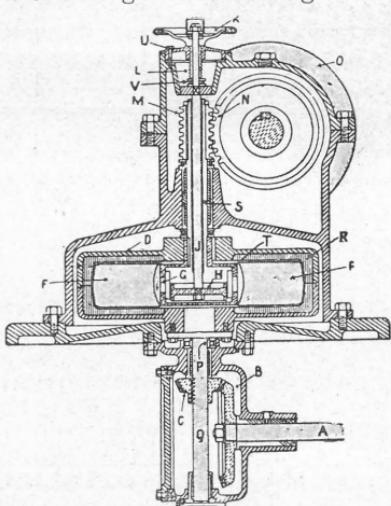
In this section we deal with the Torbinia anchor windlass, as a similar novel hydraulic transmission is employed in the new motor-driven winch under construction at the time of closing this book for press. In both cases the drive employed is a small Nat marine heavy-oil engine of the hot-bulb type, although any boat's main propelling engine will answer excellently for the purpose.

Briefly, the operating action is as follows:—The windlass is mounted on a heavy bed plate bolted to the deck, through which is carried the driving shaft and enclosed bevels from the engine. The driving shaft rotates an enclosed drum fitted with a number of interior vanes, and contains a mixture of oil and water. Running within this drum is a cage fitted with exterior feathering blades, or vanes, which are controlled to any angle by a hand wheel. A shaft and worm gearing connects these blades to the winding pulleys. As the drum rotates, the liquid is

MOTOR WINCHES

carried round, and the centrifugal force throws the liquid against the wall and pockets of the drum, and, impinging against the central blades, hydraulically transmits the power. At first it may be thought that the vanes are most efficient when set at right angles to the power. Curiously enough the greatest efficiency is obtained when the central blades are feathered to a certain angle between right angles and edge-on to the liquid, due to the side thrust; yet when the blades are feathered until they are dead edgewise no power is transmitted, and the liquid merely slips past.

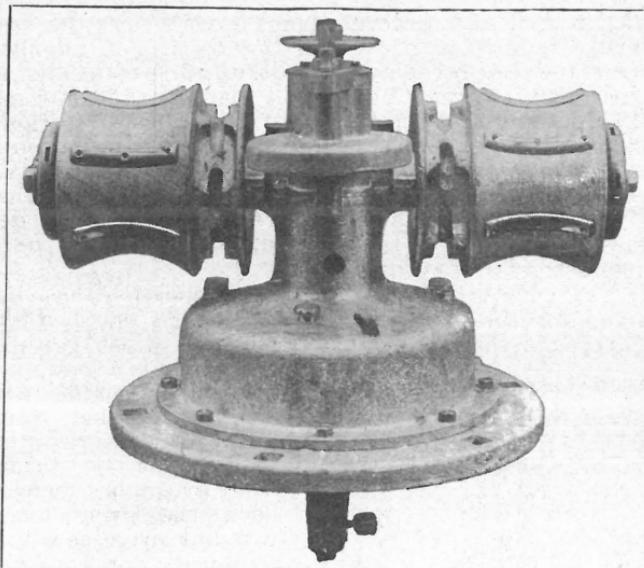
As just mentioned, the same transmission has been adapted for the Torbinia winch. On the one bed-plate and the winch, with the hydraulic gear interposed, the engine being arranged either vertically or horizontally. After passing through the hydraulic transmission the drive to the winding drum consists of duplicate worm and gear-wheel operation, actuated by eccentric motions, while control is by frictionally locking or releasing the worm drives, in addition to feathering the blades in the drum. With the latest design, however, several modifications of the worm control have been made.



Showing the operation of the Torbinia hydraulic transmission.

followed. A is the shaft from the engine, and this operates by means of the reduction bevel pinions (B) and (C) the shaft (Q), the latter being coupled to the rotating drum (D), its flange running on the ball bearings (P). As the drum (D) revolves, the liquid impinging in the pockets formed by the vanes (R) transmits the force to the blades (F). The bosses of the latter are fitted with eccentrically-mounted pins at G, which slide in slots in the flange (H). By turning the hand wheel (K) an inner shaft (J) lifts the flange (H), and thus feathers the blades. This inner shaft is bushed, and can revolve independently of the cage (T), which carries the blades. Whatever axial thrust is set up is taken by the ball-bearing (V), which is interposed between the hand wheel and the squared section of the shaft. A threaded extension (L), which works in a boss formed in the cover, is fitted to the hand wheel, and as

Turning to sectional drawing the construction can easily be



The Torbinia hydraulic anchor windlass.

the cover (U) remains stationary a turn of the hand wheel will cause the inner shaft (J) to move up and down, as before mentioned, thus deflecting the blades. Normally this shaft rotates with the blade cage, and has the vertical motion when the hand wheel is manipulated.

When the cage (T) is turned by the force of the liquid action on the blades it turns the outer shaft (S), which it will be seen runs between a pair of ball bearings, and has a worm gear (M) on its upper end. The latter meshes with a gear wheel (N) between, and keyed on the same shaft as, the two winding drums (O).

A slight variation of this design is to be found in the Torbinia anchor-capstan, which in addition to having the ordinary warping barrels are equipped with pulleys to take the anchor chains.

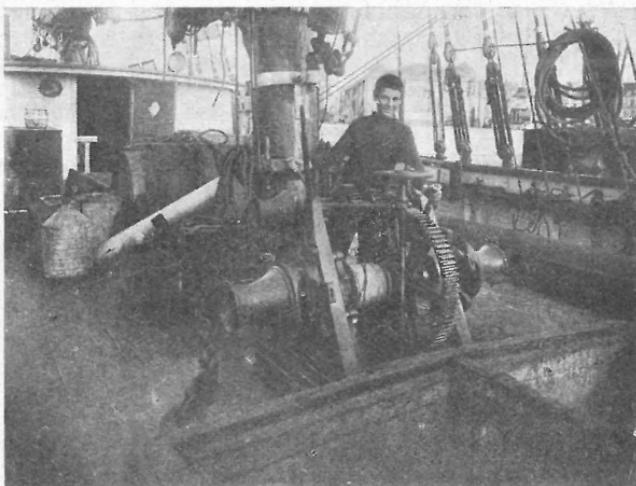
The vertical driving shaft can be thrown out of gear by means of a plate clutch situated in the casing of the engine and operated by a hand lever. Therefore, the engine can be readily started in the usual way and transmission of the power thus can be very gradual.

By opening out the controlling hand wheel the transmission it is claimed to all intents assumes a positive drive, and therefore, to get the full advantages of this system of transmission, the amount of power required to haul the anchor should only be sufficient to haul at the maximum rate required. At the same time it allows the windlass to cease to haul automatically should the load suddenly be increased by the ship rolling, and thereby

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putting a great overload suddenly on the windlass. It can quite be seen that as soon as the strain is reduced the windlass again takes in the slack of chain or exerts its maximum pull.

For lowering the anchor a brake clutch is provided, which is operated by a removable hand lever inserted in the holes on the outside of the warping drums. By moving this dog to the right or left the chain wheel can be gradually brought to rest, and the speed of lowering regulated and finally checked. Provision is made for operating two anchors on this windlass at the same time, or independently. An auxiliary hand working gear is fixed to each windlass, and this can be thrown in and out as required. The makers are the Torbinia Engineering Co., of London and Lowestoft.



*A motor-driven winch on an auxiliary schooner at Tunis
fitted with a Dan engine.*

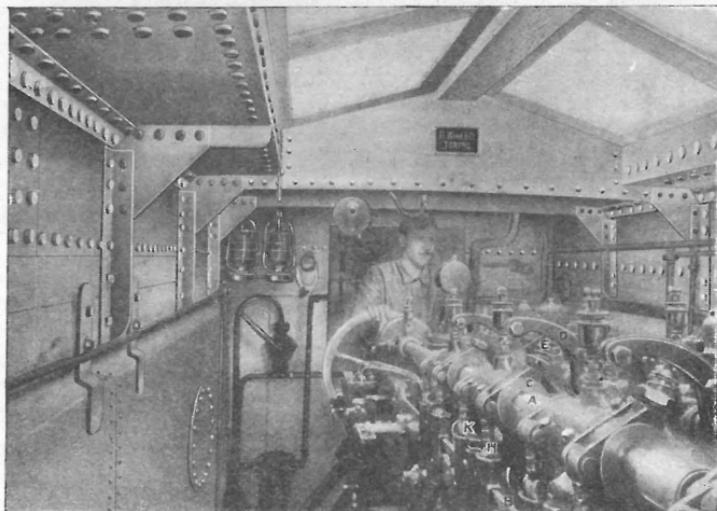
CHAPTER XVI

Diesel Engines

Their Method of Operation and Types Suitable for Fishing Vessels

OWING to the success which has been obtained with the type of motor known as the Diesel engine for the propulsion of very large vessels, the question naturally arises as to its suitability for the comparatively small commercial craft which are under consideration in this book. Before discussing this matter a few leading features of the Diesel engine may be mentioned, and its method of operation. It is constructed both as a two-cycle and four-cycle machine, whilst experimental motors have also been built working on the two-cycle double-acting principle, but these have up to the present obtained very little practical success.

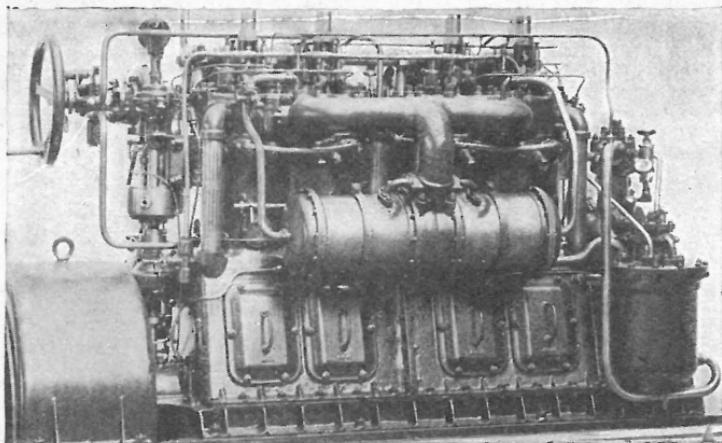
Taking the ordinary four-cycle motor as an example, its method of operation is as follows:—On the downward



Engine-room of a fishing vessel fitted with a 100 h.p. Diesel motor. The absence of boilers considerably reduces the labour and expenses, also gives the boat increased capacity, while the oil fuel affords greater cruising range.

DIESEL ENGINES

stroke of the piston, air is drawn in from the atmosphere at atmospheric pressure, and this is compressed at the upward stroke of the piston to a pressure of between 450 and 500 lb. per sq. in., the former figure being the more common. Just before the piston reaches the top of its stroke oil fuel is injected into the combustion chamber, through a specially designed fuel valve (known as a pulverizer), by means of highly compressed air from an injection reservoir at a pressure of about 900 lb. per sq. in. Owing to this high pressure and the design of the pulverizer the fuel, even though it is of a very heavy constitution, is completely atomized, and combustion takes place, due to the very high temperature of the compressed air



A 100 h.p. Daimler marine Diesel engine.

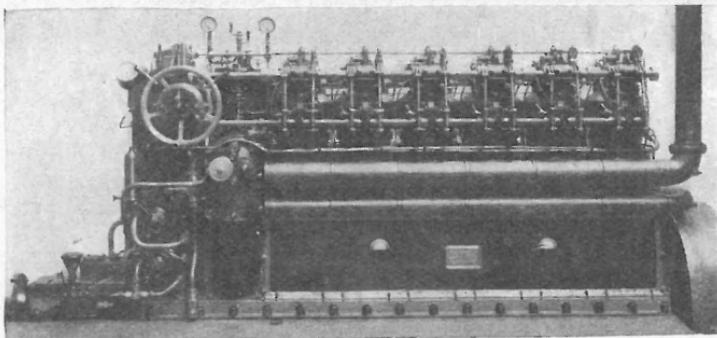
in the combustion chamber, this being perhaps 1500 to 2000 degrees F. Work is then done on the piston on the downward stroke, and the final stroke of the cycle expels all the exhaust gases through the exhaust valve arranged in the cylinder cover.

In the two-cycle motor combustion and expansion take place as before during the downward stroke of the piston, exhaust following at the latter end of this stroke through the exhaust ports at the bottom of the cylinder. In order to carry this out, scavenging air at a pressure usually of about 3 lb. per sq. in. is pumped into the cylinders either through valves in the cylinder covers or ports opposite the exhaust ports in the bottom of the cylinder. At the end of the stroke, therefore, the cylinder is full of pure air, and on the upward stroke of the piston this is compressed to the same pressure of 450 to 500 lb. per sq. in.

It will thus be seen that the main difference between the Diesel engine and the hot-bulb motor lies in the employment of a higher degree of compression (500 lb. against 150

to 170 lb. in the hot-bulb engine), and also in the injection of fuel by means of highly compressed air instead of with a pump, as in the hot-bulb type; moreover, as a rule, separate scavenging pumps are provided, and crank chamber compression is never employed, although sometimes the scavenge pumps are arranged directly beneath the working cylinders. It will be clear that no artificial heat or electrical ignition is required.

From these considerations it can readily be seen that in general a heavier type of fuel may be employed with the Diesel engines than with the hot-bulb motors, owing to the better means of pulverization, whilst if a higher temperature is obtained in compression a better efficiency of the engine is to be expected. In general the fuel consumption may be taken as being 0.4 and 0.45 lb. per b.h.p. hour, which is perhaps some 20 per cent. better than that of a corresponding hot-bulb engine. On the other hand, except in two-cycle motors, the Diesel type is very much



An 100 h.p. Kind marine Diesel.

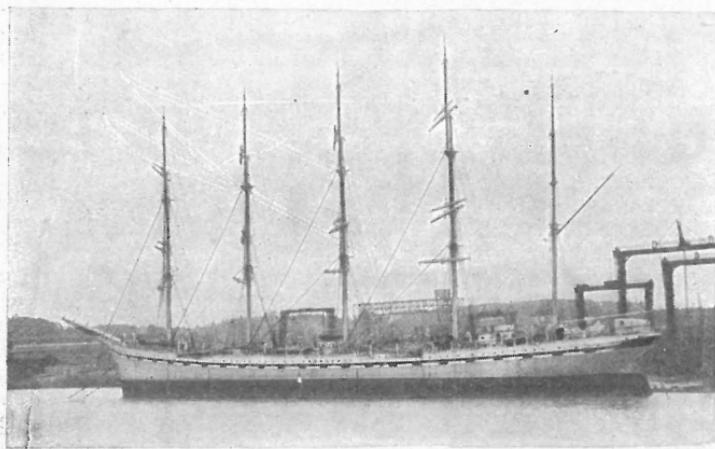
more complicated than the other, whilst the initial cost of the engine is also higher.

In any case it might at once be said that Diesel engines are practically never below powers of 50 h.p., and even this is much less than is desirable. In general this type of motor does not come into competition with hot-bulb and paraffin motors below powers of 100 h.p. to 120 h.p., and even then it is usually the four-cycle type, since the two-cycle engine is not often built, at any rate on a practical scale, under 200 b.h.p. or 300 b.h.p. Owing to the higher pressure employed, and for other reasons, the small Diesel engine is a more delicate machine than the hot-bulb motor, and needs greater care for successful operation. Moreover, its relative complication is one of its disadvantages, particularly on fishing vessels, motor coasters, and other similar commercial craft, so that it is not surprising it has made comparatively little headway for the

DIESEL ENGINES

propulsion of such vessels in competition with the hot-bulb and paraffin motors.

There are, however, undoubted economies to be obtained in the matter of fuel, and in the relatively large size of engine there is a possibility that in the future there will be a wider adoption of the Diesel engine for commercial craft, although we do not anticipate that there will be much progress in powers under 150 h.p. Even now there have been quite a considerable number of vessels built equipped with Diesel engines of about this power, including, perhaps, half a dozen fishing vessels, two or three motor coasting vessels, and a certain number of river craft. These have mostly been built on the Continent, and in this country the small Diesel engine has not hitherto been looked upon with much favour. At the present time it must be admitted that it cannot be considered as reliable a motor as that of the hot-bulb type, whilst, moreover, it is usually necessary to allow a longer time for construction, and, as mentioned before, it has the important disadvantage of involving a higher initial cost.



The largest auxiliary sailing ship in the world. "La France," a vessel of about 10,000 tons, fitted with two 900 h.p. Diesel engines.

CHAPTER XVII

The Screw Propeller

A SCREW propeller enables the engine power to be applied to the water, so that a forward thrust is produced which drives the boat. Paddle wheels and screw propellers are about equally efficient, and the best of each lose about 35 per cent. of the engine power. In order to avoid further loss of power than is necessary, the propeller should be suitable in all respects for the boat in question. When a propeller is ordered for a certain craft the b.h.p. and revolutions per minute of the engine and speed expected from the boat must all be stated. Without expert knowledge, it is almost impossible to calculate accurately the diameter and blade area required in a certain case; this is dependent upon the pitch angle required, the revolution speed of the engine, and the speed of the boat. It is, however, quite easy to tell when there is an obvious mistake in the pitch. To measure the pitch of an existing propeller, proceed in the following manner:—Mark off a spot on one of the blades at a distance from the centre of the propeller equal to two-thirds the radius, or distance from centre to the tip of blade; draw a line across the blade at right angles to its centre line, now measure the angle of the blade at this point; that is to say, the angle it makes with a plane surface held at right angles to the shaft line: this can be readily done by cutting a piece of wood in the form of a right angle and holding it against the blade so that one arm is parallel with the shaft and the other at right angles to it. Where the edges of the blade touch the arms of the piece of wood make marks, and measure the distance of each from the angle of the piece of wood. Name the arm which is held parallel to the shaft A, and the other one B, then use the following formula:—

$$6.28 \times R \times A$$

$$\text{Pitch in inches} = \frac{B}{A}$$

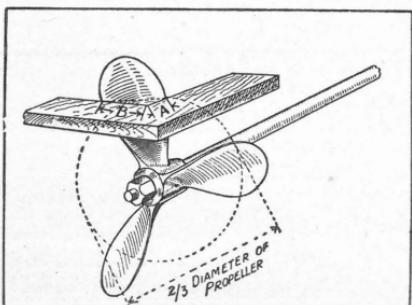
where R = two-thirds of the diameter of the propeller diameter divided by 2.

A and B are the distances measured on the arms of the wood (in any units).

The amount of pitch required varies with the type of boat and revolution speed. The following table, however, gives the pitch required for boats of various speeds with engines running at various revolution speeds based on an assumed slip of 25 per cent. Although this is not the best

THE SCREW PROPELLER

slip in every case, it is sufficiently near the average for boats propelled by fast-running engines such as motors, to be a guide in detecting an error in the pitch of an existing propeller. If the pitch of any propeller fitted to a boat is found to be in excess of the pitch given in the table to any great extent, a better result can generally be obtained by reducing it to the figure given, and this also applies to propellers whose pitch is less than shown in the table, particularly with fast-running engines. To get the best results from any boat it is always better to have the dimensions of the propeller decided by a naval architect or marine engineer, whose experience and knowledge can be relied on.



Measuring the pitch,

naval architect or marine engineer, whose experience and knowledge can be relied on.

Table showing the lineal pitch in inches required to give a normal slip of 25 per cent. at various speeds with various revolutions per minute.

Expected speed of boat (knots).	Revolutions per minute.							
	300	400	500	600	700	800	900	1000
3½	Pitch.	Pitch.	Pitch.	Pitch.	Pitch.	Pitch.	Pitch.	Pitch.
3½	18·9	14·2	11·3	9·45	8·1	7·15	6·3	5·75
4	21·7	16·25	13·0	10·82	9·3	8·12	7·21	6·5
5	27·0	20·25	16·2 1	13·5	11·6	10·22	9·0	8·1
6	32·4	24·8	19·45	16·2	13·9	12·3	10·8	9·7
7	37·8	28·4	22·6	18·90	16·2	14·30	12·6	11·50
8	43·4	32·50	26·0	27·64	18·6	16·24	14·42	13·0
9	48·8	36·6	29·25	24·4	20·82	18·6	16·25	14·64
10	54·0	40·50	32·4	27·0	23·2	20·44	18·0	16·2
11	59·4	44·7	35·7	29·7	25·5	22·3	19·8	17·85

The diameter should be equal to or a little less than the pitch where possible. A propeller should be ordered of full diameter, since it can easily be reduced in diameter and area by cutting or filing the blades. The pitch, however, should be carefully chosen to suit the boat's speed and the revolution speed of the engine.

It is not advisable for novices to try to decide the diameter and blade area of their propellers by mathematics, and the foregoing remarks are only intended to provide a means of detecting errors in existing propellers. If the engine races with a propeller whose pitch is correct, a new and larger diameter propeller should be tried.

CHAPTER XVIII

Power and Speed of Fishing Vessels

ONE of the most difficult problems connected with the use of motor power in fishing vessels is the question of the amount of power required by each boat to attain some particular speed.

It may be said once for all that, with full-bodied boats, high speeds are not to be thought of, as they cannot be got without the expenditure of such an amount of power that the expense would far more than counterbalance any advantage that might accrue from the extra speed.

However, all fishing vessels are not necessarily full-bodied, more especially those hailing from the north and engaged in the herring fishery. The Zulus and Fifies, as the two chief types are termed, are both very fine-lined vessels, capable of high speeds. Indeed, it is credibly stated that the first Fifie fitted with a motor, the "Pioneer," of St. Monance, has attained a speed of 11 knots under sail alone for a distance of 22 sea-miles, which she sailed in exactly two hours with the wind abeam. From this it is clear that if these boats can be driven at such high speeds under sail (not before a gale), they are of such a form that, with ample horse-power, they can also be driven at fairly high speeds under motor also.

So far, it is boats of these two types which have been most frequently fitted with motors, and, with the exception of the big steam trawlers from Hull and Grimsby, they constitute the backbone of our sea-going fishing fleet, so it is principally with the question of power as applied to the Zulu and Fifie that we shall now deal.

Before going into details, let us see how these two types differ from the east coast and Cornish drifters, which make up the rest of the herring fleet which follows the fish round our coasts.

The Cornishman is a boat with less beam as a rule than the east coast Scotsman, and with a more compact and deep-bodied hull, while the Lowestoft and Yarmouth boats are also fairly compact in section, but perhaps of less draught owing to their shallower fishing waters. Both are fine types of vessels and excellent sea boats, and they have this advantage over the Scotsman, that, for a given length and displacement, they have more room below.

POWER AND SPEED OF FISHING VESSELS

On the other hand, both Fifies and Zulus are beamy, hollow-bottomed boats with plenty of draught, but small displacement. Consequently, they can be driven at high speeds without excessive wave-making, while their great beam and draught gives them plenty of stability to carry sail and lateral resistance to enable them to go to windward well. Against these good qualities we must set the large area of wetted surface necessitated by the hollow bottom, which makes them harder to drive for their length and displacement *at low speeds* than the east coast and the Cornish boats.

Of the two, the Fifie is the worst offender in this respect, as she has a sternpost nearly upright and a keel with very little rake ; that is to say, she draws, say, 8 ft. aft and 6 ft. forward, while the Zulu will draw from 8 ft. 6 in. to 9 ft. 6 in. aft and less forward than the Fifie, so that her mean draught may be less than the Fifie's even when she is a slightly larger boat.

Again, the sternpost of the Zulu has an enormous rake, even greater than that of a modern racing yacht, so much so that she may have an overall length of 80 ft. with a water line of 70 ft. to 71 ft. All this means that her profile below water is cut away to something like a triangle, and as a consequence, for a given length, beam, and draught, she has far less wetted surface than the Fifie.

The effect of this is that, owing to skin friction being the chief cause of resistance at very low speeds, the Zulu should be rather easier to drive at such speeds than the Fifie ton for ton of displacement for a given length, while, owing to the Fifie's displacement being partly in her deep fine ends, and so giving her a small mid-section, she can possibly be driven at even higher speed than the Zulu without setting up excessive wave-making, while both types are capable of greater speeds for their length than the other forms of drifters built elsewhere.

It will readily be understood that all vessels vary one from the other, and that it is impossible to lay down any hard-and-fast rules as to power for speed with regard to vessels of certain lengths or even of certain displacement for a given length, as much depends on the design of the hull.

With the Zulu and Fifie types, however, the variations are so slight and the number of vessels fitted with various powered motors so great, that we have been able (thanks to the co-operation of the principal motor engineers engaged in this class of work) to get together data of a large number of vessels, and from these data to compile a table of approximate powers and speeds, which should prove useful to all concerned in this most important branch of the motor industry.

The Table of Speeds and Powers

In making this table of probable powers required to attain the stated speeds in vessels of the various types and sizes

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Table of Approximate B.H.P. for Various Speeds

SPEED IN KNOTS													
Description.		4	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{2}{5}$	5	$\frac{1}{2}$	$\frac{3}{5}$	$\frac{2}{3}$	6	$\frac{1}{4}$	$\frac{5}{6}$	7
(9 boats) Large Drifters 57/97 tons displacement	24	26	28	30	33	36	39	42	45	48	52	56	60
displacement	22	24	26	28	30	32	34	37	40	43	46	49	52
B (14 boats) Zulu and Fifies 46/72 tons displacement	18	19	20	22	24	26	28	30	32	34	36	38	40
...	18	19	20	22	24	26	28	30	32	34	36	38	40
b Vessels between B and C ...	18	14	15	16	17	18	20	22	23	25	27	29	31
C (9 boats) Small Drifters, etc, 15/32 tons displacement	8	8 $\frac{1}{2}$	9	10	11	12	13	14	15	16	17	18	19
...	8	8 $\frac{1}{2}$	9	10	11	12	13	14	15	16	17	18	19
D (42 boats) Local Line and Crab Boats 5/14 tons displacement	5 $\frac{1}{2}$	6	6 $\frac{1}{2}$	7	7 $\frac{1}{2}$	8	8 $\frac{1}{2}$	9	9 $\frac{1}{2}$	10 $\frac{1}{2}$	11	11 $\frac{1}{2}$	12
E (8 boats) Open Boats and Launches 2/5 tons displacement	4	4	4 $\frac{1}{2}$	4 $\frac{1}{2}$	5	5	5 $\frac{1}{2}$	5 $\frac{1}{2}$	6	6	6 $\frac{1}{2}$	6 $\frac{1}{2}$	7

given, it must be remembered that although these proportions of power to speed are obtained from a large number of actual results of vessels of various kinds, yet, as no two vessels are alike, and as, probably, no two vessels have exactly the same propeller efficiency, so the results obtained, although they are, as far as possible, the average of the various vessels, are not to be taken as hard and fast rules for the performance of all other boats of the same length and power, even if their displacement and other details should also agree.

On the other hand, as these results are the average of many examples, there is a fair probability that other vessels of similar dimensions and type will attain more or less the same speed for any given power, subject to the individual characteristics of each vessel.

Without going too deeply into the scientific problems of ship resistances, we may take it that any given vessel has a proportion of speed to power which varies as her speed increases. At low speeds the resistance is chiefly due to the friction of the water on the surface of her hull, which is termed skin friction,

POWER AND SPEED OF FISHING VESSELS

and to which allusion has already been made. When the speed increases this skin friction also increases rather less than as the square of the speed. Roughly, if the resistance due to skin friction in a given boat is 400 lb. at 2 knots, at 4 knots it will be a little less than 1600 lb., and at 6 knots somewhere near 3600 lb.

If skin friction were the only form of resistance to a vessel's progress, we could easily calculate the exact power required to drive her at any required speed, but, except at very low speeds, the principal resistance is due to the waves and eddies made by the vessel herself. This wave-making resistance increases very much more rapidly than the skin friction, and as it varies in each different vessel its exact proportion cannot be found out except by actual trial, and unfortunately it does not increase in any exact proportion as the skin friction does, so we must allow for a certain amount of error in any table of powers and speeds, but otherwise this table should give fairly close estimates for average vessels of each class, as the actual results from which it is compiled show both better and worse speeds for the respective powers.

To the expert it must be explained that the table has been taken from a set of curves of total resistance of groups of vessels, ignoring any humps in the actual curve of any individual vessel and taking a mean curve for each group, a little below the highest speed actually obtained, these extra figures being in heavy type.

It must be admitted that this table does not include many of the local types of fishing boats on various parts of the coast, but it was only possible to work from the data available, and we are greatly indebted to those firms who have so generously supplied this information, which includes particulars of no fewer than 77 fishing boats ranging from a 25 ft. open boat on the west coast of Scotland to a Zulu drifter 85 ft. by 21 ft. with 80 b.h.p.

In addition to the Zulus and Fifies, there are regular power drifters in which the sails are merely auxiliary (among them a steam drifter of 150 h.p. and 89 ft. o.a.). Then we have drifters and long liners from Lowestoft, Cornwall, Ireland, and Belgium, Falmouth quay punts, crabbers, and a trawler or two, so it must be remembered that our results are boiled down from many sources and must be taken as averages for each size.

When using the table, if the boat to be engined is a full-bodied type, such as some of the small boats in Cornwall and on the Irish coast, a higher power than that given for her size should be selected, whereas, if she is a fine-bodied hollow-bottomed boat, like a Scottish "Nabbie" or Loch Fyne skiff, a lower power will probably be sufficient. In the same way, we have taken the engine speed at about 450 to 500 revolutions per minute, but as some run at 290 and others at 800 to 900 or more, allowance must also be made on this score, and a somewhat higher power selected if the engine is fast running than would be necessary with low

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revolutions. This statement must not be taken as condemning all motors which run at over 300 r.p.m., as the best results out of the whole list of boats which we worked from were obtained by motors running at 500, but it may be taken as a fact that, except in certain exceptional cases, a bulky boat is best suited with a rather slow-running engine, while a finer-bodied vessel capable of higher speeds can get good results from an engine running at fairly high speed.

It was intended to publish a similar table of powers and speeds for barges and coasters, but owing to delays in getting in data of vessels, and the enormous amount of labour entailed in analysing and classifying the fishing boats alone, it has been found impossible to include the other tables in this edition, but the following examples may be of interest as giving details of various sorts of motor craft.

Coasters and Sea-going Vessels

Brigantine.—l.o.a. 155.5 ft., l.w.l. 131 ft., beam 33 ft., draught 12.9 ft., displacement 568 tons, power 150 b.h.p., speed 6 knots.

Coasting schooner.—l.o.a. 174 ft., l.w.l. 153 ft., beam 27 ft., draught 10.2 ft., displacement 735 tons, power 190 b.h.p., speed 7.75 knots.

Coasting schooner.—l.o.a. 93 ft., l.w.l. 87 ft., beam 23.5 ft., draught 10.5 ft., displacement 300 tons, power 47 b.h.p., speed 5.5 knots.

Coasting schooner.—l.o.a. 120 ft., l.w.l. 103 ft., beam 20 ft., draught 7 ft., displacement 250 tons, power 30 b.h.p., speed 3.9 knots.

Lighters and Barges

Lighter.—l.o.a. 150 ft., beam 18 ft., draught 6 ft., displacement 350 tons, power 35 h.p., speed 4.7 knots.

Lighter.—l.o.a. 60 ft., beam 18 ft., draught 4.5 ft., displacement 90 tons, power 45 h.p., speed 5.5 knots.

Lighter.—l.o.a. 60 ft., beam 15.3 ft., draught 6 ft., displacement 120 tons, power 24 h.p., speed 5.2 knots.

Canal barge.—l.o.a. 75 ft., beam 15 ft., draught 4 ft., displacement 96 tons, power 20 h.p., speed 4.3 knots

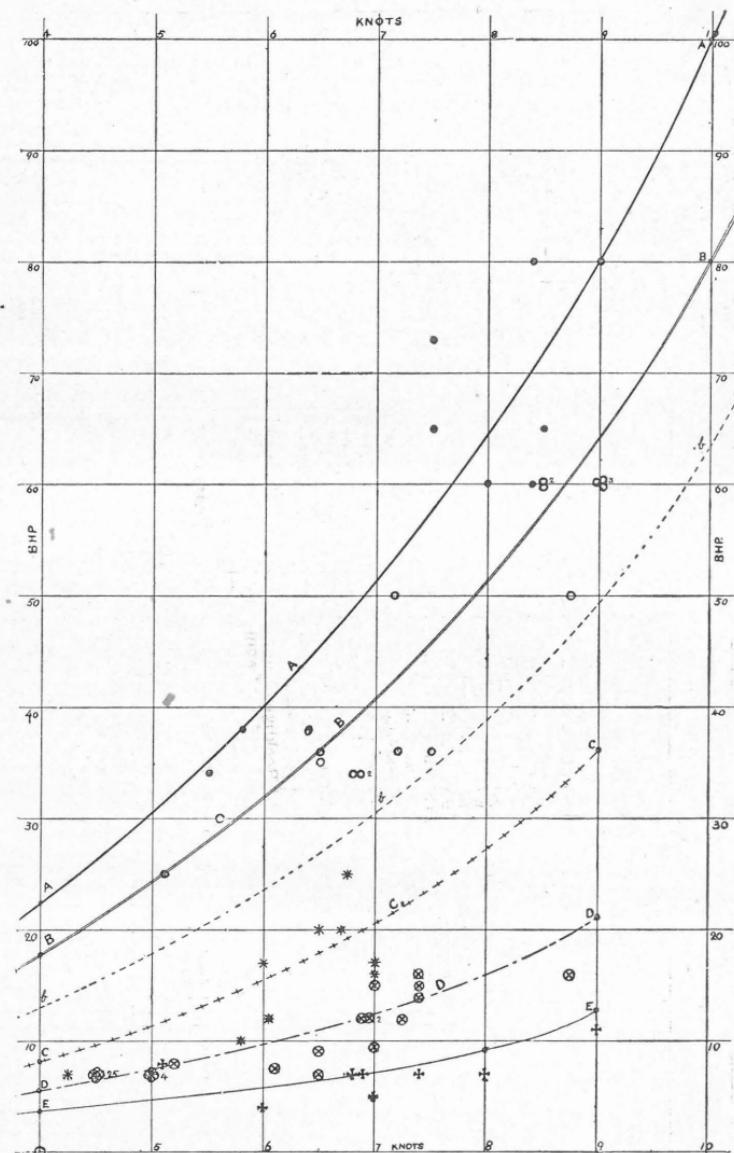
Tugs

Tug.—l.o.a. 50 ft., beam 10 ft., draught 6.5 ft., displacement 22 tons, power 80 h.p., speed light 9.25 knots.

Canal tug.—l.o.a. 45 ft., beam 7 ft., draught 3.5 ft., displacement 13 tons, power 28 h.p., speed light 8 knots.

Canal tug.—The same boat towing 12 barges, total 400 tons displacement, 1.8 knots.

POWER AND SPEED OF FISHING VESSELS



Curves of power and speed obtained from data relating to existing vessels and from which the table previously given was drawn up.

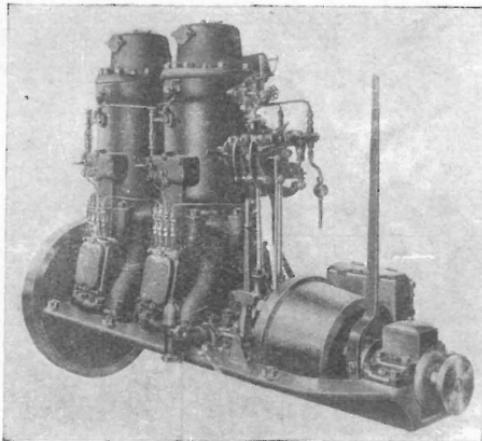
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General Name.		National Names.		Trade Names.		Remarks.		Spg.	Flash.	Boil.	B.T.U.	No.	
PETROL		Light Spirits ..		(Gasolene ..				•635 to .690		Below 0°		20,500	
		Anglo Gasolene ..		Air-gas Spirit ..		Anglo Vaporising Spirit ..		.690 to .720		50° to 140°		20,000 to 21,000	
		Swan Spirit ..		Pratt's Perfection ..				.690 to .720		Below 0°		7	
		Shell Spirit ..		Mex Spirit ..				.690 to .720		50° to 140°		6	
		Carburine ..		Shale Naphtha ..				.690 to .720		Below 0°		7	
		(E) Petroleum Spirit ..		(E) Taxibus ..				.690 to .720		50° to 140°		6	
		Naphtha ..		(E) Crown ..				.690 to .720		Below 0°		7	
		Gasoline ..		(A) Glico ..				.690 to .720		50° to 140°		6	
		Benzine ..		(F) Benzoline ..				.690 to .720		Below 0°		7	
		Essence ..		Benzine ..				.690 to .720		50° to 140°		6	
PARAFFIN		Paraffin ..		Naphtha ..				.690 to .720		50° to 140°		6	
		Petroleum ..		Benzole* ..				.690 to .720		Below 0°		7	
		Kerosene ..		Benzole* ..				.690 to .720		50° to 140°		6	
		Petroe Lampant ..		Benzole* ..				.690 to .720		Below 0°		7	
		Leuchtoel ..		Benzole* ..				.690 to .720		50° to 140°		6	
L I G H T O I L		(E) Victoria ..		Crown Diamond ..				.800 to .826		78° to 88°		19	
C R U D E O I L		(E) Empire ..		Crown Diamond ..				.800 to .826		78° to 88°		19	
L I G H T O I L		(A) Rocklight ..		Crown Diamond ..				.800 to .826		78° to 88°		19	
L I G H T O I L		(F) Rocklight ..		Crown Diamond ..				.800 to .826		78° to 88°		19	
L I G H T O I L		(G) Rocklight ..		Crown Diamond ..				.800 to .826		78° to 88°		19	
L I G H T O I L		Homeight V.O. ..		Crown Diamond ..				.800 to .826		78° to 88°		19	
L I G H T O I L		Homeight V.O. ..		Crown Diamond ..				.800 to .826		78° to 88°		19	
L I G H T O I L		Gladiator ..		Crown Diamond ..				.800 to .826		78° to 88°		19	
L I G H T O I L		Brownsine V.O. ..		Crown Diamond ..				.800 to .826		78° to 88°		19	
L I G H T O I L		Brownsine ..		Crown Diamond ..				.800 to .826		78° to 88°		19	
L I G H T O I L		R.V.O. ..		Crown Diamond ..				.800 to .826		78° to 88°		19	
L I G H T O I L		R.V.O. ..		Crown Diamond ..				.800 to .826		78° to 88°		19	
L I G H T O I L		Oil Engine Oil (Shale) ..		Standardised Oil for Engines ..				.825		86°		31	
L I G H T O I L		Oil Engine Oil (Shale) ..		Standardised Oil for Engines ..				.798		99°		32	
L I G H T O I L		Oil Engine Oil (Shale) ..		Standardised Oil for Engines ..				.798		99°		32	
L I G H T O I L		Less Lubritants, Solids and Impurities.		Ordinary Lamp Oils ..				.800 to .826		78° to 88°		19	
L I G H T O I L		Bear Creek ..		Ordinary Lamp Oils ..				.800 to .826		78° to 88°		19	
L I G H T O I L		Rocklight Lamp ..		Ordinary Lamp Oils ..				.800 to .826		78° to 88°		19	
L I G H T O I L		Homeight Lamp ..		Ordinary Lamp Oils ..				.800 to .826		78° to 88°		19	
L I G H T O I L		Homeight Diamond ..		Ordinary Lamp Oils ..				.800 to .826		78° to 88°		19	
L I G H T O I L		Crown Diamond ..		Ordinary Lamp Oils ..				.800 to .826		78° to 88°		19	
L I G H T O I L		Crown Diamond ..		Ordinary Lamp Oils ..				.800 to .826		78° to 88°		19	
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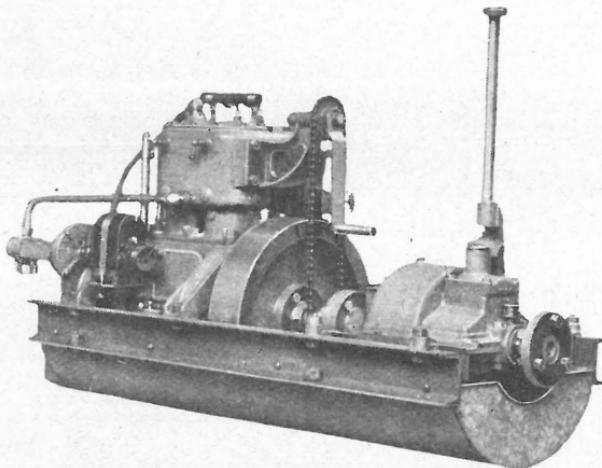
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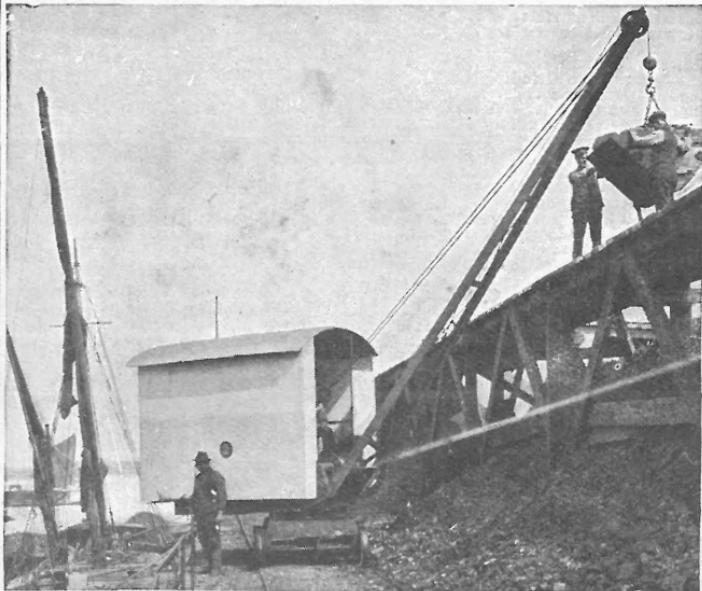
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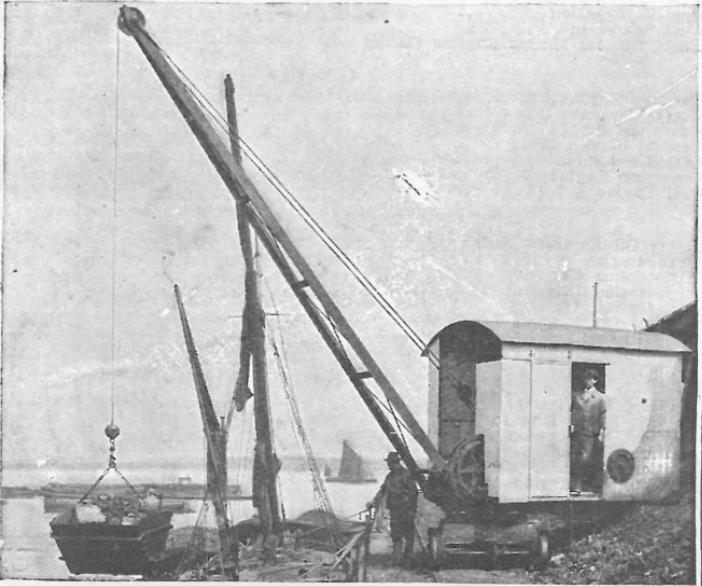
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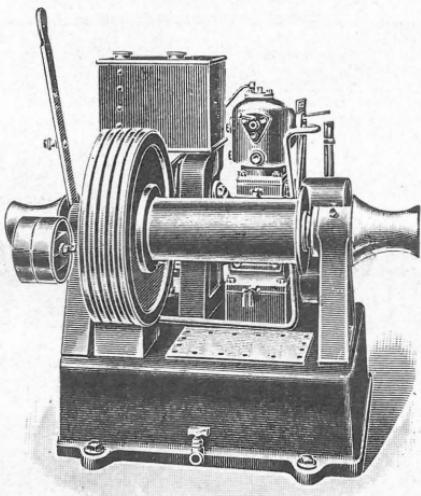
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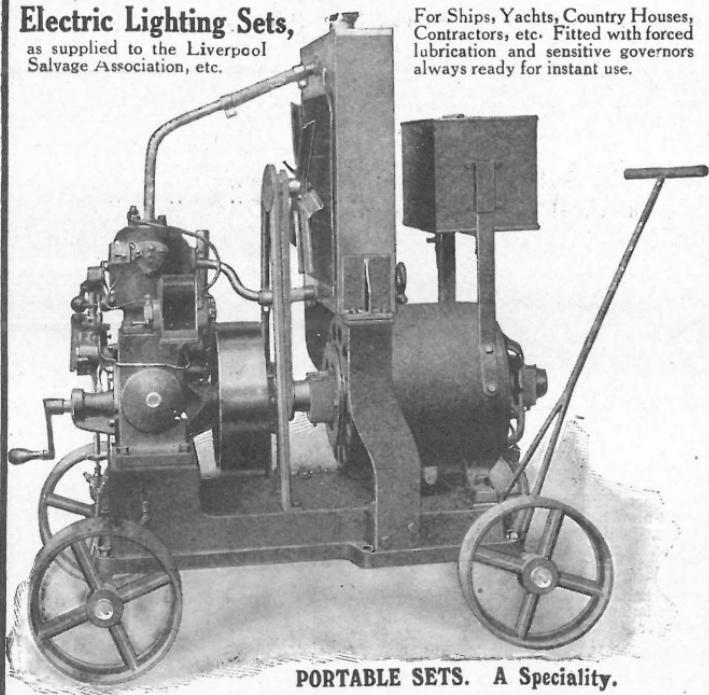
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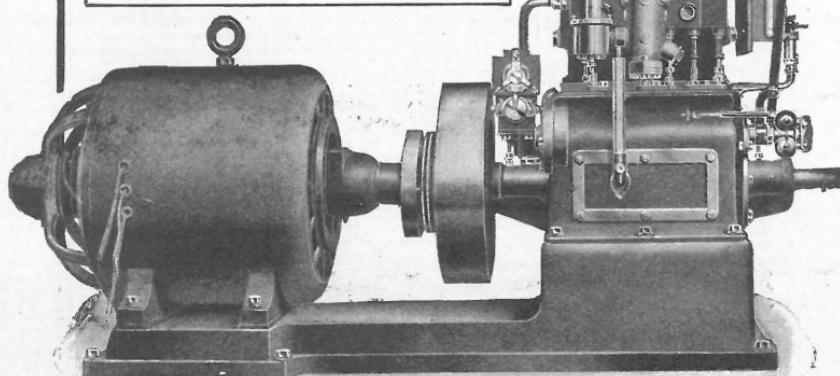
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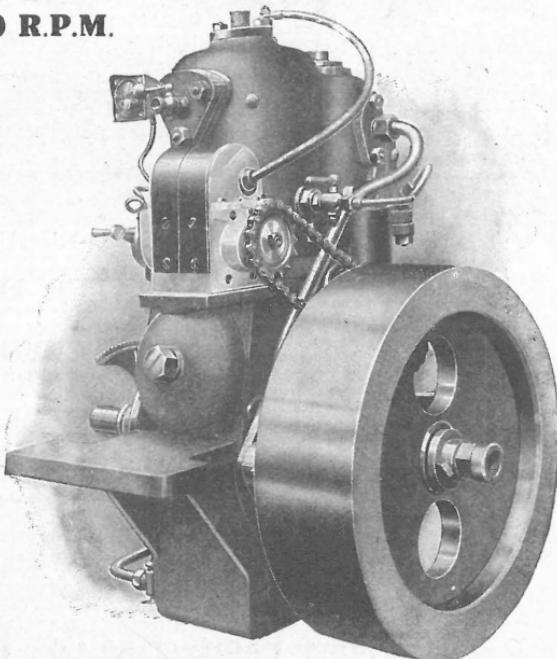
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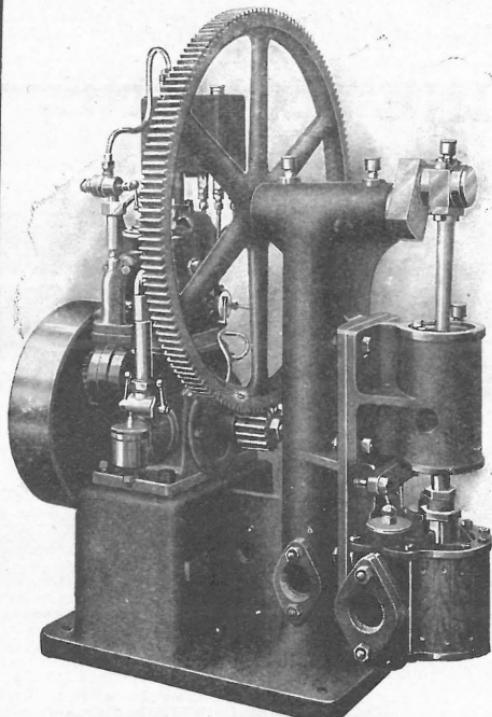
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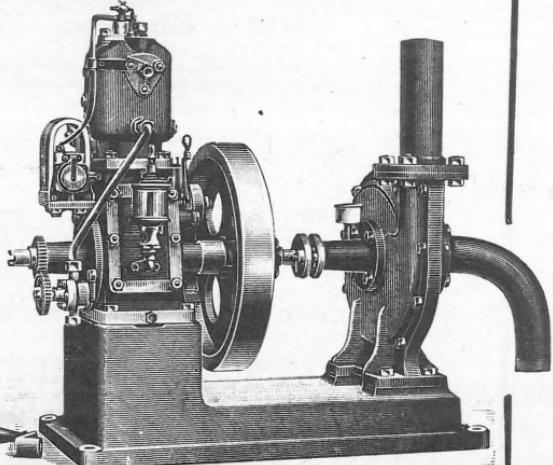
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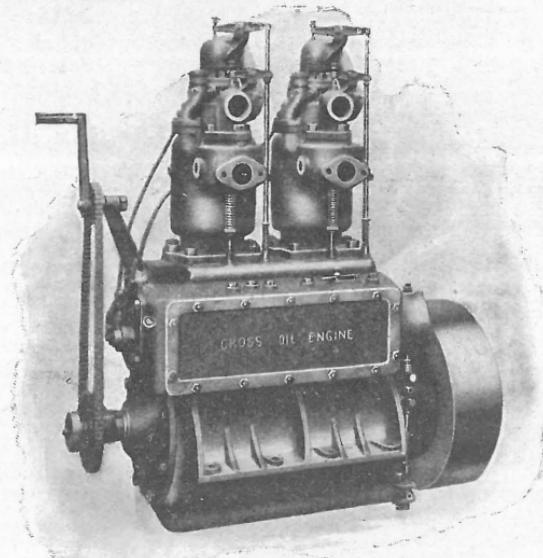
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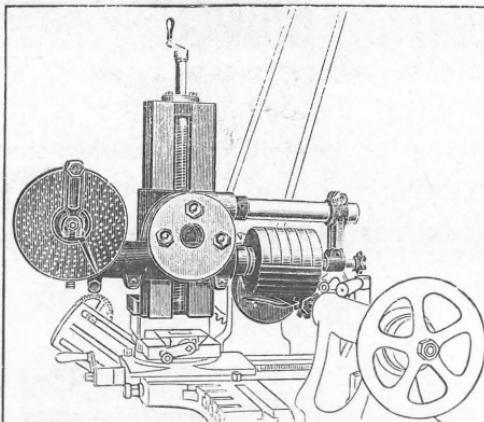
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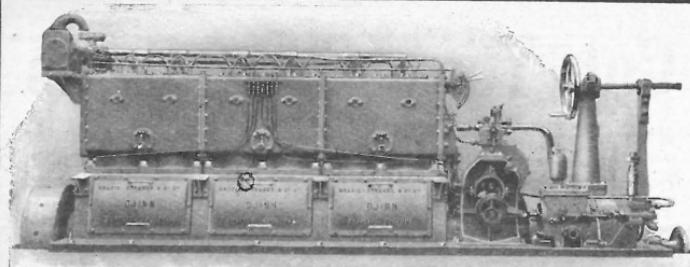
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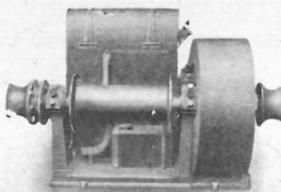
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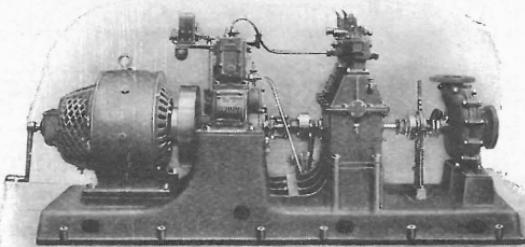
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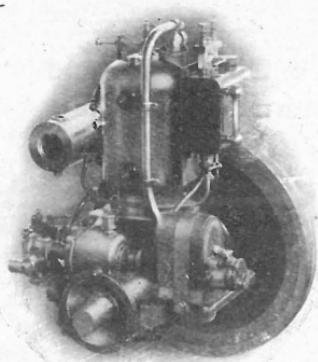
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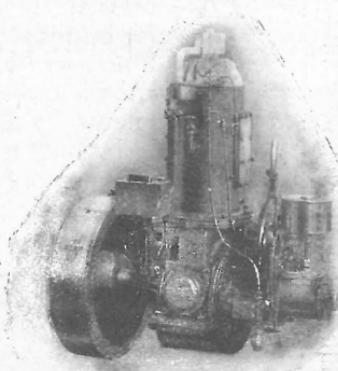
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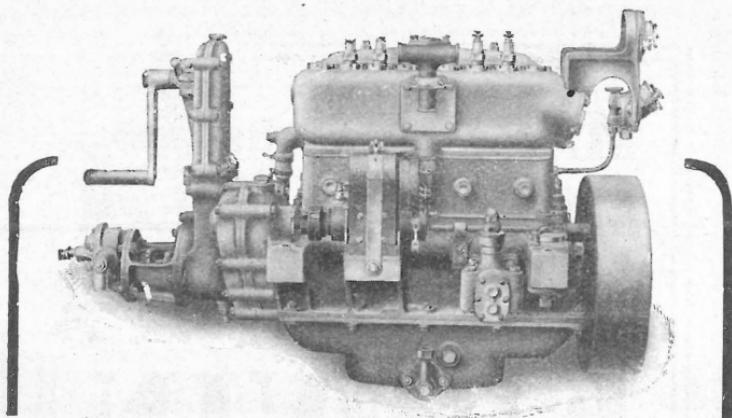
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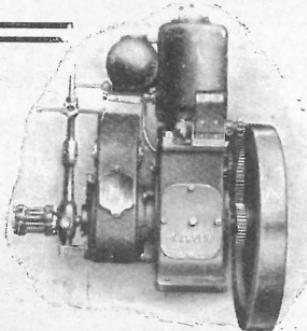
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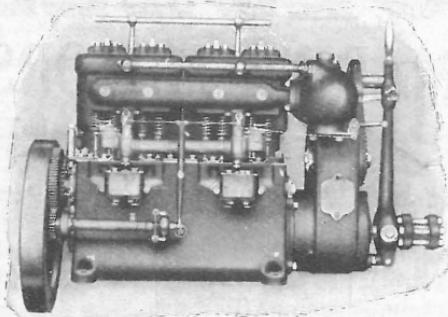
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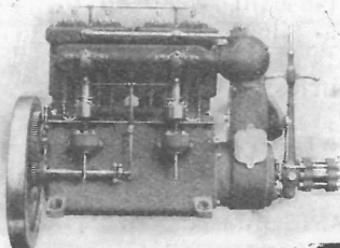
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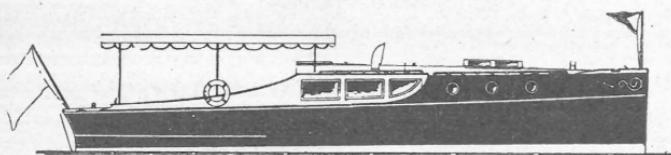
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